POWER PLANT ENGINEERING

THE PLANT ENGINEERING AND MAINTENANCE MAGAZINE FOR EVERY INDUSTRY

atures In
his Issue

Watts Bar Steam Plant
Practical Engineer and Electrician
Gear Friction and Lubrication
Plattsburgh Produces Power
Voltage Regulators

OCTOBER
1941

KILOWATTS

Tanks, ships, planes, powder, guns,— we've got to have them — in enormous quantities and fast. But first come plants and the power to energize the production facilities which turn out these important defense items. Power is primary to production.

Serving the needs of defense, Elliott equipment is at work in plants everywhere — in Navy Yards, in Navy and commercial vessels, in power plants, in industrial plants producing equipment directly or indirectly essential to defense.

And power generation is only part of the picture. Feedwater systems demand protection against corrosion. Circulating water lines must eliminate trouble-causing solid matter. Boiler tubes must be kept clean. In these and other vital matters of maintenance, as well as in power generation, Elliott equipment is heavily engaged.

Dependable power is essential to defense. Elliott equipment insures dependable power.

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POWER PLANT ENGINEERING

OCTOBER, 1941
VOLUME 45, No. 10

Cover: Arthur Thomm, coal hoisting engineer at the Harwick Mine, is shown operating equipment which hoists an average of 4200 tons of coal from the seam 300 ft. below the surface. (Photo, courtesy Duquesne Light Co.)

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PUBLISHED MONTHLY BY

TECHNICAL PUBLISHING CO.
53 W. JACKSON BLVD.

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CLEVELAND: George E. Andrews
11733 Edgewater Dr., Lakewood, O.

Subscription price $2.00 a year in the United States and Possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copy current issue 25c; back issue 40c.

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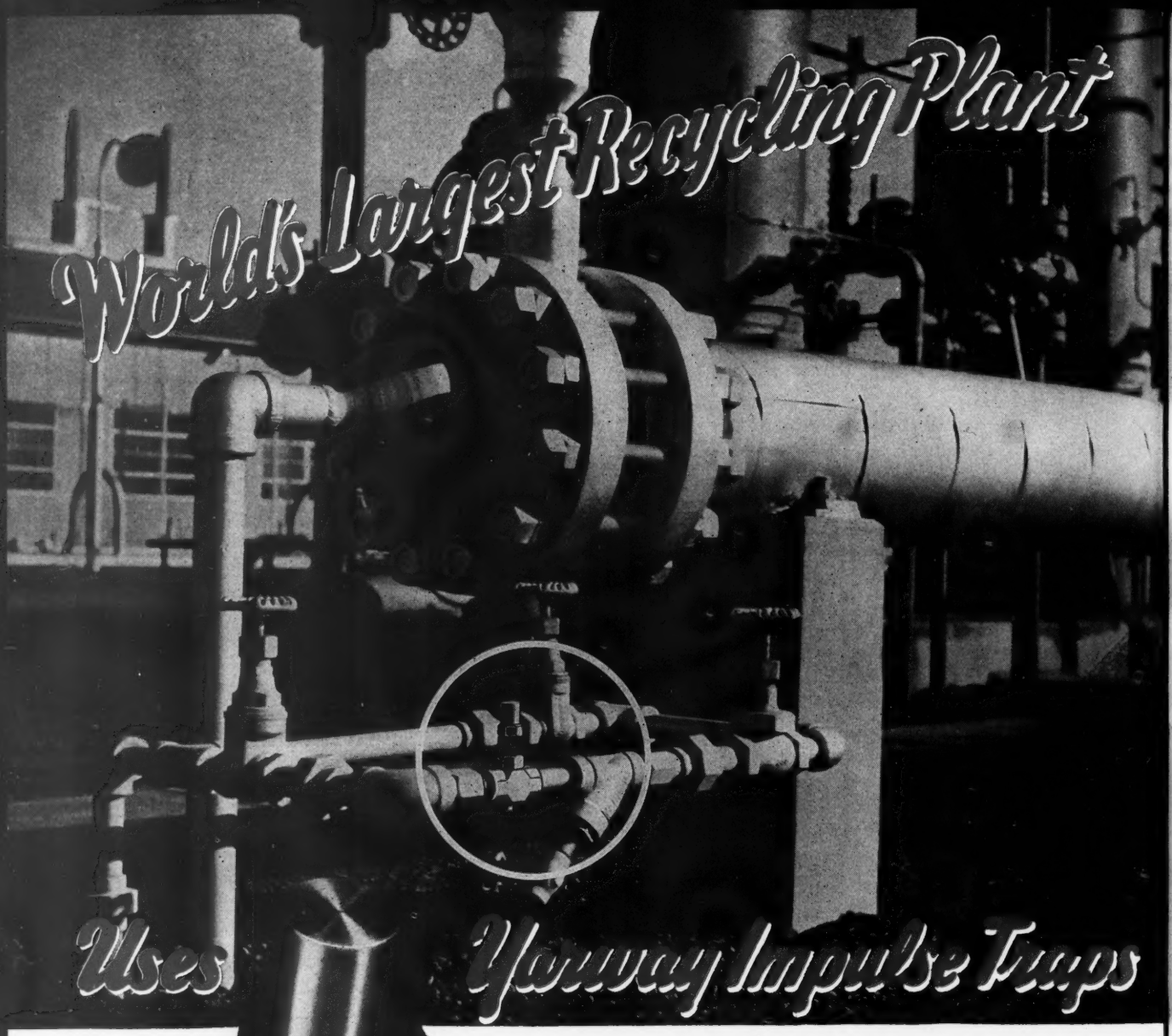

AT the Coastal Recycling Company Plant at Corpus Christi, Texas, said to be the largest plant of its kind in the world, Yarway Impulse Traps are in use on gas heaters (illustrated), steam mains and other equipment, both indoors and outside exposed to the elements.

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THE VOICE OF INDUSTRY

Philip D. Reed

Charles E. Wilson

PHILIP D. REED and CHARLES E. WILSON on GENERAL ELECTRIC'S DEFENSE PRODUCTION

GENERAL ELECTRIC'S biggest and most important job for defense involves building the units which drive the Navy's fighting ships and vessels of our expanding Merchant Marine. These propulsion units make up the powerhouse—the vital organs—of a modern ship. The tremendous speeds at which the turbines operate are reduced to propeller shaft speeds by means of reduction gears, also made by General Electric.

In addition, auxiliary turbines are needed for generating the electricity used by power equipment and by control devices, as well as for light and communication.

Another vitally important defense product is the supercharger for aircraft. In the development of turbo-superchargers General Electric was again a pioneer. Turbo-superchargers are driven by the exhaust gases from airplane engines, and some idea of the engineering and manufacturing problems which must be faced in producing them may be obtained when it is realized that they must operate at tremendously high speeds and at temperatures which would melt ordinary metals.

Because of our experience in building similar equipment, we have also been asked to produce other aeronautical accessories, such as generators, propeller motors, and a variety of delicate aviation instruments. The successful operation of modern fighting aircraft requires extreme accuracy and efficiency of these accessories, and we have fully utilized our vast research facilities in improving and perfecting them.

Firing a big gun is not today simply a matter of getting the range and direction and pulling the lanyard. Such factors as wind direction and velocity, temperature, atmospheric density, state of tide, and even the rotation of the earth, must be taken into account. More than twenty different operations are now performed in bringing a big gun to bear on its target, and throughout the process electricity plays an important part. General Electric is producing the motors and control and the calculating devices which make possible the fast and accurate firing of modern ordnance, and this work is proceeding according to, or ahead of, schedule.

We are making hundreds of searchlights for the Army and Navy. Each army unit, which is of 800,000,000 candlepower, is accompanied by its own portable power plant, for in the field it must have an independent power supply not only to feed its sunbright core but also to raise and lower the light and to direct its beam.

Effective co-ordination of land, sea, and air forces at modern speeds is made possible by radio. We are making large quantities of radio transmitting and receiving equipment for all three branches of service. By careful planning and by pretraining of men, we were able to put into immediate operation a large new factory which was constructed in 57 days.

We have also been successful in eliminating other bottlenecks in our own plants by subletting operations to skilled shops which are equipped to handle the work. In several cases we have contracted for the full 24-hr. day output of shops whose facilities were available. This constant search for additional facilities is the major concern of one of our committees.

Much of the more intricate and highly technical defense equipment we have now been called upon to produce in such great quantities, was conceived and developed in the past by the men of science in our Research Laboratory. Today the full resources of that Laboratory, and the experience and talent of its staff, are being utilized to solve newer problems, and that effort may well give birth to ideas which will shape the course of things to come.

The substantial expansion of our plant facilities would not have increased our capacity in the least had we not been able to provide the personnel to operate it. In training personnel we have also looked ahead. Wherever a new factory is being built, workers are being trained to man the machines which it will house. Last year 18,600 new employes were added to the payroll of the Company, most of them going directly into defense work or into training for defense work. So far this year we have been adding more than a thousand employes each week. More than 500 foremen are now supervising defense work alone in our factories.

Regular appentice and other training courses have been greatly enlarged. In addition, each of our plants is giving short, intensive courses of training to new employes on specific single operations. This plan has the advantage of speed, and is producing excellent results.

In the final analysis, the success of our whole program depends upon the men and women in the factories, in the laboratories, and in the offices of the Company. Never, in any industry, has there been better co-operation and teamwork than has been evident in your company during this critical period.

PHILIP D. REED and CHARLES E. WILSON have been chairman of the board and president respectively, of the General Electric Co. since 1939. Mr. Reed, born in Milwaukee, holds degrees in both electrical engineering and law and joined General Electric in 1926, at the age of 27. Mr. Wilson, born in New York, began working at the age of 13 as an office boy of the old Sprague Electric, a former constituent of the General Electric. Since then he has served in practically every branch of the business. Each in his way exemplifies the opportunities offered by American industry, a forceful demonstration that success depends neither on age nor formal education.

National Defense production is now playing a dominant role and was the dominant theme in a quarterly report to the stockholders issued April 25. "We have moved from the blueprint and tooling-up stage into . . . production . . . in steadily increasing quantities" says the report which has been summarized here briefly, with reference to established production omitted and only the more unusual lines mentioned.

Photometric Visualizers

NO, LADIES* AND GENTLEMEN, this young man is not nuts; he is not trying to get out of the rain by trying to get under this funny little umbrella, in fact it isn't raining at all and it isn't an umbrella. What is it? Well, frankly it is a photometric visualizer, but don't let that floor you because really it is quite simple to understand if you can forget the high sounding name. These little gadgets (there are two of them, a small one and a tiny one) are three-dimensional plastic models, constructed to the scale of 500 candle-power to the inch, of light distribution from streetlights. Technically known as Photometric Visualizers, they are used in General Electric's Illuminating Laboratory to show the effectiveness of various types of luminaires—light fixtures to the "man-on-the-street." The butterfly-appearing model which seems to please lighting engineer S. B. Gaylord so much represents the amount and distribution of light produced by one of the newest type luminaires. The tiny one at the right is a model, on the same scale, of the light from the best unit of 25 years ago. The increased distribution of light represents only one phase of the great progress in the art of illumination. Recently, much work has been done on the development of protective lighting systems and so-called anti-sabotage lamps. An example of a unit in the latter category is shown among the various photographs on page 71 of this issue.

*We assume, and hope, that there are a few ladies who occasionally look through Power Plant Engineering.

WITH THE EDITORS

● **WHY BE CAREFUL?** . . . Spying and malicious destruction are two of the internal dangers in the nation today, as is always the case when a war is in progress and sympathy and aid are being given to one of the combatants. So far, such sabotage as has been proved may likely be the efforts of individuals rather than perfected activity of organized groups of foreign agents. Also every accident which occurs in industry is not sabotage and there has been no great increase in the number of such accidents, spite of the great increase in employment, which in many cases is of workers on unfamiliar jobs.

Nevertheless, it is important that all possible precautions be taken to prevent stealing of vital information about defense work and the destruction of buildings, equipment and products vital to our defense program.

It, therefore, behooves every industrial manager to examine his operating activities with the purpose of reducing to a minimum the likelihood of espionage and sabotage in his plant and organization.

● **DANGER POINTS?** . . . In regard to espionage, information sought will very likely be blueprints of machinery and of defense products manufactured, of specifications and formulas, of working models, production methods, capacity, rate of production, contracts and deliveries. Spies may use ingenious methods to obtain the information they want and their detection is a job for the trained men of F.B.I. There is no need for workers or the general public to suspect everyone as a spy, but every citizen should remain vigilant at all times and any actions indicating possible anti-American or subversive activities should be reported immediately to the nearest office of the F.B.I.

In plants essential to the defense program, even in a minor degree, obviously credentials and identification should be required of all workers and no strangers should be allowed in the plant except on proved legitimate business and with proper guides.

● **THE F.B.I. EXPERIMENTS** . . . To show what may happen where proper supervision is lacking, in one F.B.I. survey an agent entered each of three entrances without hindrance and toured the entire plant without being questioned, even securing confidential information from workmen as to activities. In another instance, visitors, after passing the gate, were free to wander at will through the plant on the way to the office. Evidently checking at the gate plus guiding of visitors to their destination was needed here.

In another plant, while those in charge of engineering followed the order to guard blueprints of war material carefully, it was found that the vault in which prints were locked up for the night had an outside window of ordinary glass which could easily have been forced and the confidential plans stolen. A third plant had a careful system of checking out blueprints, but no investigation had been made as to reliability of the man in charge of this checking, who had recently been hired. Fortunately, this man was proved to be a loyal American citizen, but these incidents show the need of vigilance in protecting such material.

● **WHAT TO DO** . . . Plant survey is now under way for some 2500 plants, probably later increased to 12,000, as to arrangements for safeguarding against spying and sabotage. Studies have been made of methods in use, of fire prevention safeguards, and special training given to surveyors, including chemistry, bacteriology, explosives, document examination and codes. Also a manual of instructions on plant surveys has been prepared.

Recommendation as to employes is that each one be given a credential card, on special type of safety paper, having on it employment number, name, physical description and photograph, to be presented at entrance doors or gates. As additional identification, a badge, of color and shape to designate the department, with name and employment number be carried or worn by each employe when on plant property. This would ensure the validity of all employes and would call attention to unwarranted activity of an employe outside his own department.

In order to secure concerted effort in law enforcement, conferences of police officials are held at central points in industrial states and members of law enforcement organizations are pledging themselves to co-operation in safeguarding internal security and defenses.

● **MISCHIEVOUS DESTRUCTION** . . . Disabling of plants, damaging of materials and supplies, crippling of power are among the objects of the saboteur. The chief objects of attack, buildings, machinery, materials and products, water supply, transportation and blueprints or formulas may be damaged by fire, breakage, explosion or chemical action, and prevention of such damage involves fire precautions, safety rules, and strict safeguarding of chemicals, blueprints, specifications and confidential information as to plant, methods and processes.

In one factory, a pile of oil-soaked metal shavings was found in a warehouse where oil and gasoline were stored, with excess oil running into small pools on the floor, so that a stray cigarette end or burning match stub might easily start a conflagration. In another plant, a room for baling waste paper was found with fire extinguishers which had not been inspected for 5 yr. In a shop with valuable machinery, floors were oil soaked, clothes and waste were kept in non-fireproof containers, fire fighting equipment was inadequate and smoking was allowed. Emery dust and graphite, used in the shop, were easily available to anybody bent on mischief.

Secret model of an airplane, under test in an experimental hangar, was guarded only by a flimsy partition in which a hole had been kicked by somebody who wanted to see the model.

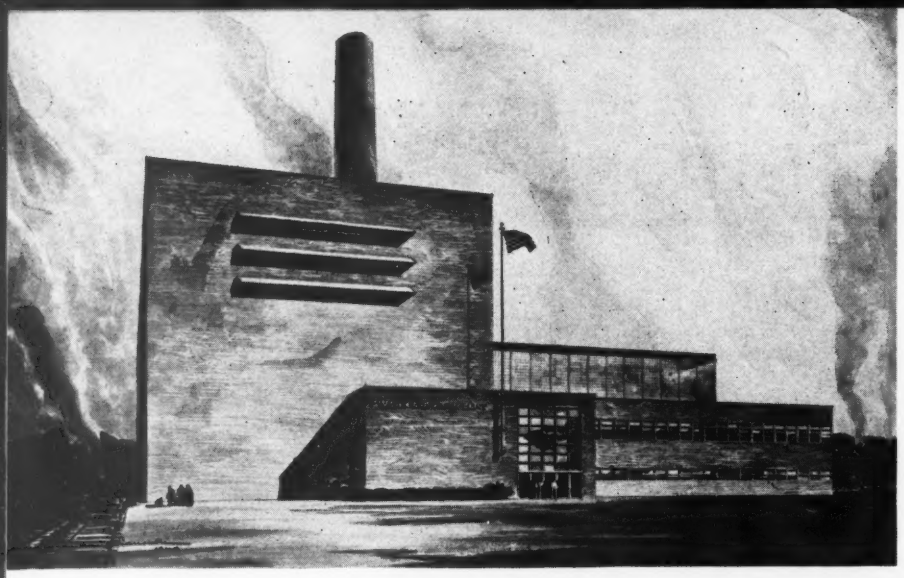
It is such conditions which are uncovered by the F.B.I. surveys and which should be prevented by executives responsible for safety of plant and equipment.

Protection of power supply is vital, as failure of power will cripple the activities of any industrial plant. Hence, it is vital that all in any way responsible for personnel or equipment in the power supply system should be constantly alert to safeguard that supply against sabotage in any form. Generating plant, supply lines, distribution centers and power drive should have regular inspection to ensure that protection is adequate, properly maintained and safeguarded against unauthorized meddling.

● **FIRE! FIRE!** . . . October 5 to 11 is the annual Fire Prevention Week. Down through the years, business and industry have been responsible for the majority of the advances that have been made in fire prevention and protection. Now, with defense the paramount issue in every American's mind, it is fire which threatens our internal security more than any other destructive agency.

Not only must we continue to contend with fires originating largely from carelessness — which losses involve some 10,000 lives and $300,000,000 annually—but also, we must now take into consideration war incendiarism—sabotage and incendiary bombs.

All of the problems of normal peace time fire protection are intensified in the present emergency. Maintenance of continuity of production is the major objective. In many critical industries the monetary loss due to fire may be of minor importance compared with the interruption to production which any major fire entails, particularly at the present time when the replacement of machinery, materials and equipment may involve long delays.



Tennessee Valley Authority rushing a new 850 lb., 900 deg. F. steam plant to completion to supplement hydro-capacity and supply defense power. Three 60,000-kw. units in the initial section with provisions for a fourth unit later. Located adjacent to the Watts Bar Hydro Plant, the new steam station will take circulating water from the Watts Bar pool, without pumping, and the electrical control and 154 kv. switchyard is combined for the two plants

WATTS BAR STEAM PLANT

BY F. E. BELL
Construction Engineer
Watts Bar Steam Plant
Tennessee Valley Authority

WHEN THE EFFECT of the "Fall of France" was fully realized by those responsible for the Nation's defenses, the eyes of the Nation were focused on the necessity of more armaments and airplanes. To produce these implements of war in sufficient quantity to guarantee the fulfillment of our needs required an immediate increase of electricity. The creation of and the progress made by the Tennessee Valley Authority have made available a vast amount of electricity for defense purposes. Although to date the Authority has been able to supply large blocks of power, it was felt that this hydro-generated power must be supplemented with reserve steam-generated power. It is the intent of the following resumé to outline the progress made in erection of a 180,000-kw. steam plant for this purpose.

Reasons for selecting the Watts Bar Dam location for this plant were varied and adequate. The economic axiom of money, men, and materials fitted the choice of this location admirably, for in an undertaking of this scope, greater economy is accrued by having immediately available an organization properly equipped and staffed to do the job.

The site chosen was excellent for foundations in that the entire structure is resting on unweathered shale with a load-bearing value of 3.6 t. per sq. ft. Although the overburden consisted mostly of clay, which necessitated the use of exterior wall forms, a considerable percentage of the concrete for the interior deep wells was poured directly against the rock.

Shortly after the authorization to proceed with the erection was granted by Congress, and before excavation plans were completed, excavation was started. Naturally, many changes were to be expected, but no major difficulties have been encountered.

The building is designed so as to be a watertight concrete box from bed rock at Elev. 683 to

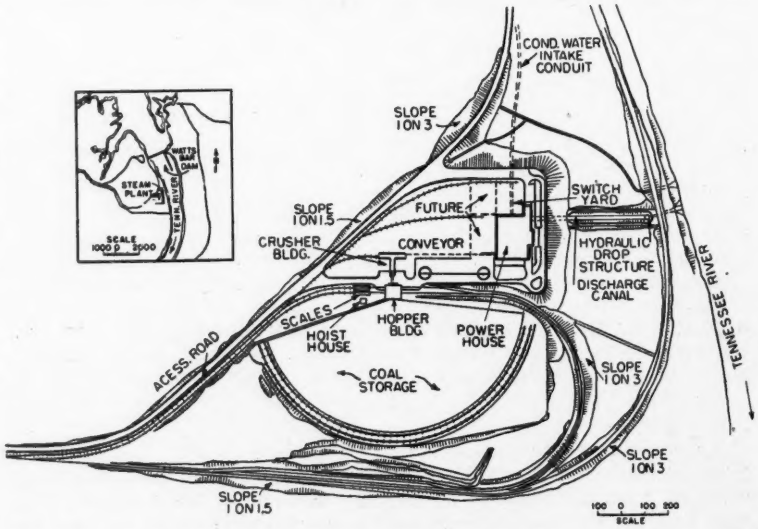


Fig. 1. General plan of the Watts Bar Steam Plant site with insert showing its relation to the hydro plant and dam

ground level at Elev. 731. Particular care was taken in the design and the installation to insure against ground-water seepage, especially at times of high water in the Chickamauga Lake. The construction joint seals are of the same type and construction as those successfully used in hydro installations.

Formwork and Building

Practically all forms for the exterior walls were built in the dam carpenter shop and transported to the site, except those for the coal-handling structures and such places as were deemed uneconomical and impractical to use shop-fabricated units. This procedure made use of the skilled form carpenters who had had several years of experience in building complicated scroll-case and draft-tube forms for the dam construction. All inside wall forms were lined with 3/8 in. thick sheets of Celotex which added materially to the appearance of the surface. This will also "case harden" the concrete. The additional cost of lining the forms was approximately 3 ct. per sq. ft.

Because of the general characteristics of the turbine foundations, especially those of concrete, the lining of these forms was found to be impractical as the quantity of reinforcing steel required prevented free access for vibrating or spading. As a consequence, tongue and grooved form lumber was used with ends matched at corners so as to eliminate unsightly board marks. This procedure required more careful planning than usual, but the results obtained were considered to be worth the extra precautions taken. The question of whether or not to pour the foundations as a monolith was given careful study by the designers, with the result that they were poured in three lifts, approximately 10 ft. high. Ten or more days lapsed between successive pours. Extreme care was taken to clean the forms of all debris, before pouring, as well as to have the pours made slowly and evenly. The appearance of the foundations justified the precautions taken to insure a pleasing concrete surface.

The building is of steel framing encased by brick and glass block. There are approximately 2400 t. of steel in the structure, somewhat greater than usual on account of the type of boilers. These boilers are suspended from the supporting members which occasioned the use of 384 lb. H columns. The steel was erected by the combined use of a guy derrick and a traveling locomotive crane. The derrick was jumped twice during the erection.

Concreting had progressed sufficiently to permit steel erection, in the boiler room, December 1, 1940. However, inability to procure material from the mills delayed erection until February 12, 1941. Considerable delays occurred even though TVA sent representatives to the shops not only to expedite, but to assist in the layout and prosecution of the work. These delays increased the cost of erection slightly on account of not providing steady work for the ironworkers, many of whom came from the East expecting continuous employment. Costs were also affected by the necessity of working overtime in order to permit installation of the equipment.

There are no windows in the building except in the service-bay section, on the second floor of which are the offices for the plant operators. The offices will be air-conditioned. There is no partition wall between the turbine and boiler rooms; consequently, sufficient light will be admitted by the glass block, above the turbine-room crane rail, for general illumination in the daytime. The interior of the turbine room and public lobbies will be finished in a manner to present a pleasing and harmonious appearance similar to that in lobbies and public spaces of existing hydro stations in the Authority.

This present building is for two units, but excavation work is now under way for the addition of the third unit. Although the installation of the fourth unit has not been authorized, the building excavation is being undertaken now, and the exterior foundation walls will be installed.

Shortly after the authorization to proceed was granted and the major equipment purchased, designs for the structure were completed so as to place the structural steel order. It was thought at first

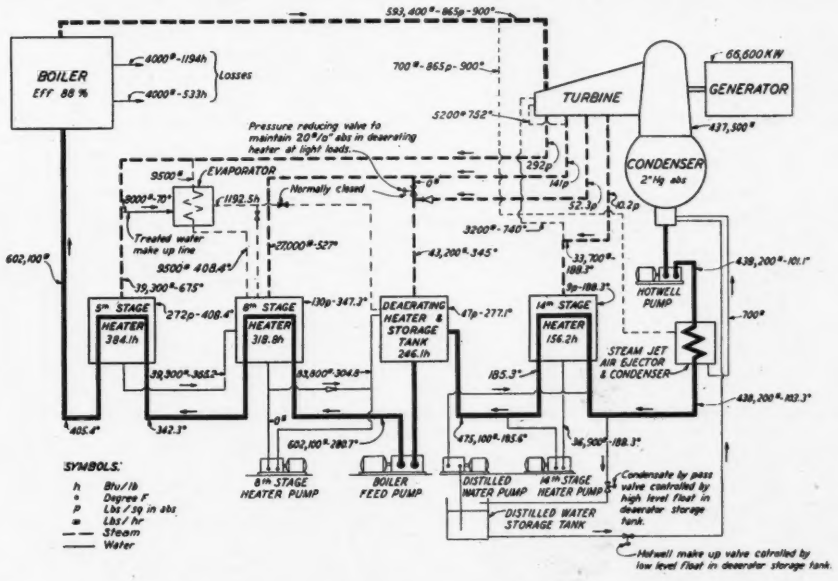


Fig. 2. Heat balance diagram of one unit for full load conditions. Three closed and one deaerating heater are included in the cycle, with an evaporator between the fifth and eighth stage extraction points. No circulating pumps are required for the water is taken under positive head from the hydro plant pool

that there would be considerable difficulty in installing the station equipment, for the details of construction of the various heaters, tanks, and other items were not available. However, later events proved that, although much was desired as to such information, there were no obstacles to prevent a balanced thermodynamic design and excellent equipment arrangement.

In this connection, for instance, Fig. 3 illustrates the distilled water storage tanks located under the floor in the center of the building. To prevent alkaline infiltration from the concrete, these tanks, one for each boiler, are completely lined with carbon brick. Extreme care was taken to install these linings according to the instructions furnished by the manufacturer, and no deviations from the specifications were permitted.

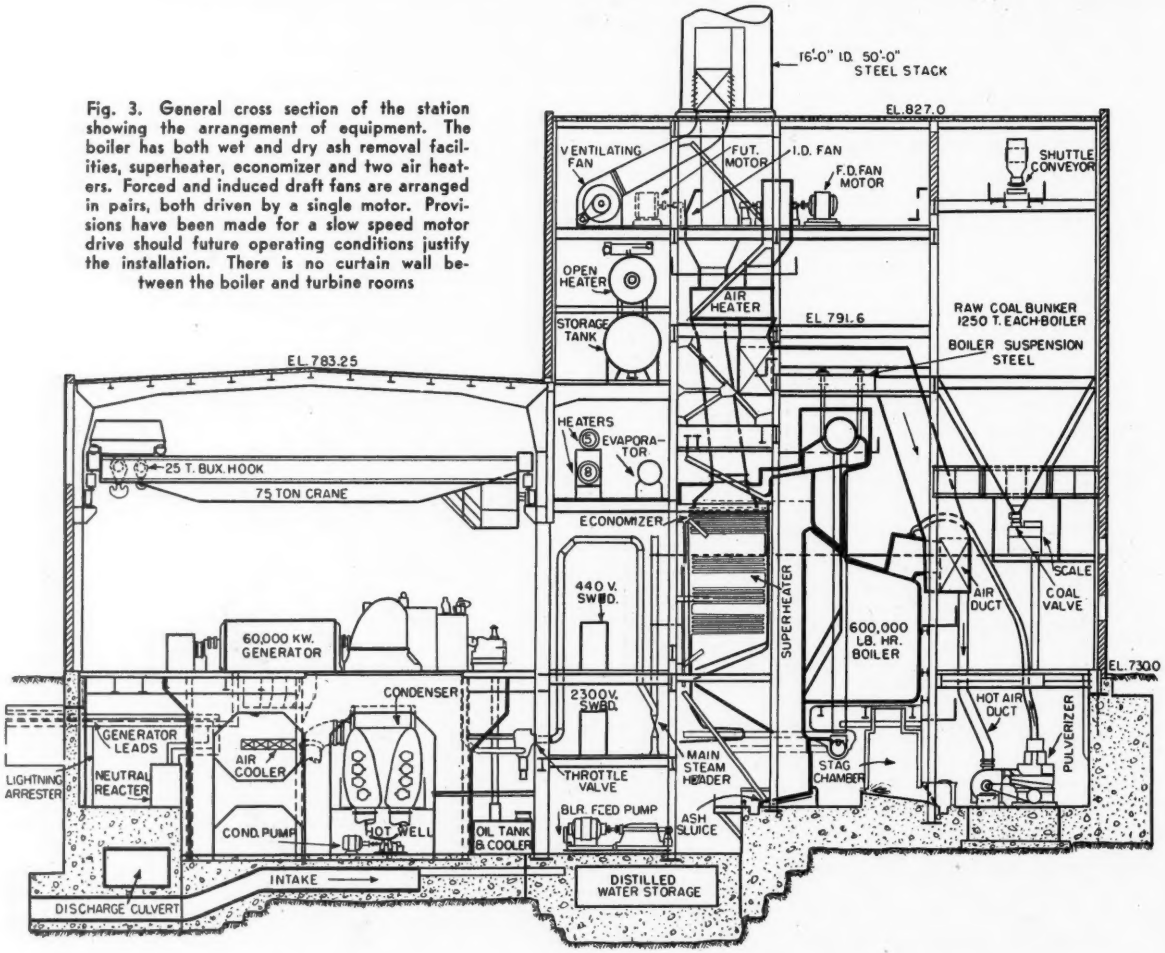


Fig. 3. General cross section of the station showing the arrangement of equipment. The boiler has both wet and dry ash removal facilities, superheater, economizer and two air heaters. Forced and induced draft fans are arranged in pairs, both driven by a single motor. Provisions have been made for a slow speed motor drive should future operating conditions justify the installation. There is no curtain wall between the boiler and turbine rooms

Coal Handling and Storage

This system conforms to generally accepted standard practice, deviating to the extent that provisions were made for the receipt of coal by rail and truck and possibly by water at a later date. The structures to enclose equipment for such deliveries entailed considerable study by the designers as well as complicated construction problems.

The storage area, south and west of the buildings, covers approximately 10 acres, and will provide storage for about 200,000 t. of crushed coal. The storage area is serviced by a drag-line type of reclaimer, as shown on Fig. 1, with control from the lookout tower in the hopper building. To eliminate the necessity of power haulage of the empty cars away from the hopper building, the return track has a four per cent grade for about 200 ft., and from that point on there is a one per cent grade to the empty car siding.

Crushed coal from the utility building is delivered to the bunkers by 36-in. belt conveyors at an ultimate rate of 400 t. per hr. The raw coal bunkers have a storage capacity of 1250 t. per boiler, or sufficient to operate each boiler at full capacity for 40 hr., thereby eliminating the necessity of working the coalyard forces over the weekends.

Circulating Water System

Adoption of the use of the Watts Bar Lake for cooling purposes, instead of pumping, has been detailed in papers[1] by Messrs. Rich and Mathews and Mr. Chambers. The placing of the 78 in. precast pressure pipe presented some interesting problems as it was necessary to schedule the installation at a period when the dam construction program would be least affected. The pipe line passes under the cement-unloading hoppers, and the open cut parallels the access railroad to the cement-unloading building for approximately 1200 ft.

It was not deemed advisable to remove the cement-unloading hop-

[1]To be presented at an A.S.M.E. meeting, October, 1941.

Fig. 4. Placing the 78 in. precast circulating water line. Due to the proximity of cement unloading hoppers embedded in rock and the wind anchors for the temporary bridge in the background, the pipe line was tunnelled for approximately 100 ft. This view is looking upstream toward the tunnel section

pers which were embedded in rock. The wind anchors for the temporary construction bridge are embedded in rock at close proximity to the hoppers. Consequently, this portion of the pipe-line excavation was tunneled for a distance of approximately 100 ft. Figure 4 illustrates this tunnel section. In the soil-overburdened sections a backdigger hoe proved both advantageous and economical.

This pipe was fabricated on the site under subcontract to the Lock Joint Pipe Co. The Authority furnished cement and aggregates and installed the pipe under the supervision of a representative of the company.

Extreme care was exercised in the selection of aggregates to produce the best results. The pipe was cast in 12 ft. lengths. The reinforcing steel consisted of $\frac{3}{8}$ in. longitudinal bars, spaced at approximately 27 in. on center, and spiral hoops on 3 to $3\frac{7}{8}$ in. centers between angular rings, depending on the pressure. The wall thickness of the pipe was 7 in. The contract specified that a minimum of 96 lineal feet of pipe be cast daily. The contractor experienced no difficulty in meeting this requirement.

To secure the proper gradient of the line, a 12 in. fill of sand was placed in the trench before the pipe sections were laid. Traveling caterpillar cranes were used to place the sections. To expedite the construction progress of the entire project, as stated above, the installation of the pipe line was started at the hydro-end, working 24 hr. a day. Closure was made near the steam plant end of the line. With the addition of the third unit it became necessary to install an additional pipe line, and this operation is now under way.

The intake structure, properly equipped with trash racks, traveling screens, sluice gates, and auxiliary machinery, is located upstream at right angles to the dam axis. Inasmuch as it forms a physical adjunct to the hydro powerhouse, it was constructed by the construction and engineering organization on the dam.

To regulate and shut off the intake circulating water to the condensers, two 42 in. motor-operated butterfly valves are provided for each unit. To prevent syphoning of the discharge from the condensers, there is an open canal that forms a stilling pool, the overflow of which discharges into a hydraulic-drop structure and then into Chickamauga Lake. To prevent the backing up of the lake into the drop structure, when cleansing is warranted, it will be possible to close the discharge by stop logs at the outlet of the drop-structure tunnel. A small earth-filled crib cofferdam faced with steel sheet piling was built into the lake to permit construction of these structures.

Boilers and Turbogenerators

Three steam-generating units are being installed under subcontract to the Babcock & Wilcox Co. The details of type and other pertinent information are listed in the Summary of Principal Features at the conclusion of this article. Realizing the amount of time necessary to erect boilers of this capacity was the primary consideration in awarding the structural steel contract at the earliest possible date. The original schedule contemplated single-shift erection, but priority ratings for the armed services precluded the delivery of essential components of the boilers in time to permit installation during one shift; consequently, it is necessary for the subcontractor to work multiple shifts to meet the present scheduled date.

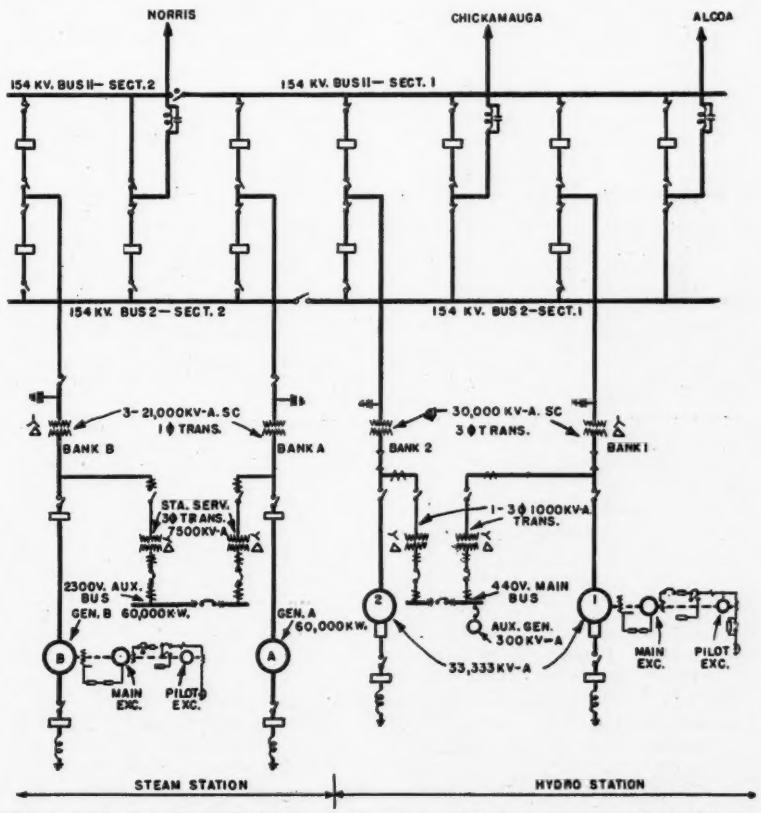


Fig. 5. Single line electrical diagram of the steam and hydro stations and the combined 154 kv. high tension switchyard

The ash handling system is of conventional design and conforms to standard practice in this type of construction. However, with this type of boiler there is a dry-ash hopper as well as a molten-slag hopper as shown in Fig. 1. The ash will be disposed in low areas adjacent to the site. This equipment is manufactured by the Allen-Sherman-Hoff Co.

Turbogenerators are of the General Electric Co. manufacture, the details of which are in the Summary of Principal Features. Before the first two units can be placed on their foundations, the construction of the foundation piers for the north outside wall and the rectangular conduit section of the intake circulating water conduit must be completed. These operations will permit the erection of the turbine-room steel up to the operating floor on which the access tracks are located. Otherwise, it would be necessary to build temporary bents for access to the foundations.

Heat-balance diagram, Fig. 2, shows the flow of these systems, boiler feedwater, condensate and feedwater-treating systems and further details of each are listed in the Summary of Principal Features.

Electrical features and arrangements for the plant are shown by the one-line diagram, Fig. 5. The general consideration for locating the steam plant in close proximity to the hydro-plant made it economically possible and feasible to control both of the plants from a centrally located control room. There is a duct bank of thirty-five 3 in. fibre conduits connecting the control room, overlooking the hydro-plant, with the control board in the turbine room at the steam plant. Facilities are installed in the steam plant for starting up and shutting down the plant, but it is normally placed on the load by the operator in the central control room. However, in case of an emergency, the steam units may be placed in service by the turbine operator at the plant.

Power is generated at 13,800 v. and is stepped up to 154,000 v., at the switchyard at the steam plant site, for transmission to the main switchyard which also serves the five hydro units.

SUMMARY OF PRINCIPAL FEATURES — WATTS BAR STEAM PLANT OF THE T. V. A.

Initial Operation—January, 1942.

Location—On west bank of the Tennessee River, about 3500 ft. below Watts Bar Dam.

Generating Capacity—Installed capacity—199,800 kv-a.; 180,000-kw. at 0.9 p.f. Maximum continuous capacity (3000 hr.)—180,000-kw.

Powerhouse Structure—Concrete substructure. Structural steel, brick, and glass block superstructure. Operating floor level, El. 731; basement floor, El. 699; boiler room roof, El. 827. Height from boiler room floor to boiler room roof, 120 ft. Boiler room dimensions (approx.) 191 by 99 ft. Turbine room dimensions (approx.), 182 by 84 ft. Turbine room crane, 75 t. capacity; 78 ft. span. Smoke stacks, two 16 ft. by 50 ft. unlined steel, on boiler room roof.

Boilers—Babcock & Wilcox Co. Number of units, 3. Type, 2-drum, open-pass; two (open-pass and water-cooled dry) ash removal hoppers; continuous slag tap primary furnace; continuous blowdown. Rated capacity (each unit), 600,000 lb. steam per hr. Steam at superheater outlet, 850 lb. per sq. in. pressure, 900 deg. F. t.t. Boiler design pressure, 1000 lb. per sq. in. Total furnace volume, 27,000 cu. ft. Total water wall heating surface, 11,504 sq. ft. Boiler efficiency (full load), 88.23 per cent.

Fuel—Pulverized bituminous coal from East Tennessee and East Kentucky. Fuel consumption (3 units, full load)—2250 t. per da.

Firing Equipment—Babcock & Wilcox Co. Burners (per unit), 8 multiple intertube, vertical firing. Pulverizers (per unit), 4, type E, with integral fans and 200-hp. constant speed induction motor drive.

Superheaters—Babcock & Wilcox Co. Horizontal continuous tube; tubes 2½ in. O.D. with a total superheater heating surface of 17.120 sq. ft.

Economizers—Babcock & Wilcox Co. Steel tube; tubes 2½ in. O.D. with a total economizer heating surface of 17,070 sq. ft.

Air Heaters—Air Preheater Corp. Two per unit; Ljungstrom regenerative, vertical flow. Heating surface 45,000 sq. ft. each; 90,000 sq. ft. per boiler.

Fans—American Blower Corp. Induced draft (per unit)—2. Forced draft (per unit)—2. Fans coupled together in units consisting of one forced and one induced draft fan; each unit driven by one 800-hp., 720 r.p.m. direct-connected, constant speed, induction motor.

Control—Bailey Meter Co.—complete automatic combustion and superheat control for each unit.

Ash and Slag Handling—Allen-Sherman-Hoff Co., hydraulic sluice system discharging to disposal area in plant yard.

Coal Handling—Jeffrey Mfg. Co. (conveyor) and Sauerman Brothers, Inc. (drag scraper). Type—Belt conveyor with drag scraper for storage, initial capacity, 400 t. per hr. Storage capacity: boiler room bunkers (per unit), 1250 t.; yard, 200,000 t. Coal delivery to site initially by rail, with provision for future delivery by rail, water, and truck.

Turbine Units—General Electric Co. Number, 3. Type, single casing, single flow, 17 stage, 1800 r.p.m. turbines with extraction at 5th, 8th, 11th, and 14th stages and extraction pressures of 243, 129, 49.5, 10.4 lb. per sq. in. abs. Operating conditions—850 lb. per sq. in.; 900 deg. F. at throttle with 28-in. vacuum. Generator rating, 66,600 kv-a.; 60,000-kw. at 0.9 p.f., 3-ph., 60 cycle, 13.800 v., 1800 r.p.m. Exciter, 180-kw., 250 v., direct-connected. Pilot exciter, 4-kw., 250 v., direct-connected. Surface air cooler.

Condensers—Foster Wheeler Corp. Three, single-pass, cross-flow, surface condensers with a total condenser tube surface (per unit) of 40,000 sq. ft.

Condenser Circ. Water—Gravity flow from lake above Watts Bar Dam through two 6 ft. 6 in. concrete pipes 3200 ft. long. Intake screen house in reservoir above dam. Circulating water per unit at full load, 70,200 g.p.m. Circulating water temperature, 76 deg. F.

Condensate Pumps—Foster Wheeler Corp. Number (per unit) 2. Type, 3-stage, pressure sealed, centrifugals, 1160 r.p.m., 300 ft. total head, 1100 g.p.m., 125-hp. constant speed induction motor drive.

Feedwater Pumps—Ingersoll-Rand Co. Number, 4 (1 pump per unit; 1 spare). Type, 6-stage, centrifugals, 3550 r.p.m., total dynamic head 1200 lb. per sq. in., 1290 g.p.m.; 1250-hp. constant speed induction motor drive.

Feedwater Heaters—Westinghouse Elec. & Mfg. Co. Type, closed for 5th and 8th stages. Capacity, 632,500 lb. per hr. Shell design pressure, 300 lb. per sq. in. Tube design pressure, 1500 lb. per sq. in.

Feedwater Heaters—Worthington Pump & Mach. Corp. Type—Deaerating on 11th stage. Capacity, 600,000 lb. per hr. Maximum operating pressure, 50 lb. per sq. in. Storage tank capacity, 100,000 lb.

Feedwater Heaters—Westinghouse Elec. & Mfg. Co. Type—Closed on 14th stage. Capacity, 641,000 lb. per hr. Shell design pressure, 50 lb. per sq. in. Tube design pressure, 150 lb. per sq. in.

Piping—Grinnell Co., Inc., Piping Contractor. Main-steam, boiler-feed, condensate, and other essential piping systems completely welded by electric welding and electric annealing.

Electric System—Control from Watts Bar Hydro Plant control room and individual unit boards at Steam Plant.

Main Transformers—Maloney Electric Co. Number—9. Type, 21,000 kv-a., single phase, self cooled, outdoor. Generator switching at 13.8 kv. Main transformers in steam plant switchyard step-up 13.8 kv. generator voltage to 154 kv. for transmission. Main high-voltage transmission switching in combined hydro steam plant switchyard at 154 kv.

Co-ordination of Water Conditioning With Operating Problems. II

Part II. Prevention of deposits from water is the theme of this second and last article of the series. Part I which dealt with the maintenance of a protective film was published in the September issue*

BY R. E. HALL AND C. E. KAUFMAN
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IN GENERAL, make-up water for the modern boiler plant is treated by one or more processes to render it more suitable for feedwater. Filters, evaporators, softeners of different types as lime-soda, sodium and hydrogen zeolite, or phosphate, acid treatment, and various processes for removal of silica, offer a considerable diversity of procedures from which to choose. For each water, in accordance with the proposed conditions of its use, choice of treatment should be made which will economically effect adequate removal of such constituents as suspended matter, hardness, organic impurities, and silica, and at the same time, leave in the water the minimum concentration of dissolved solids.

In spite of all that can be done to purify the feedwater, remnant impurities concentrate in the boiler water, requiring establishment of conditions therein which will inhibit formation of adherent scale.

The first principle to follow in conditioning the boiler water is to establish and maintain those equilibria for calcium and magnesium which assure their separation as nonadherent sludge and not as scale.

One factor in obtaining this end —the alkalinity of the boiler water —has been discussed in Part I of this series of articles published in the September issue. It should be pointed out, however, that in those cases in which treated, as opposed to evaporated make-up, is considerable, alkalinity must necessarily be higher than in the low or evaporated make-up plants, in order to hold the sludge more completely in suspension.

The other factor to consider is the maintenance of a concentration of carbonate or phosphate radical which will insure the precipitation of calcium as nonadherent calcium carbonate or phosphate, and not permit calcium sulphate or silicate to form. High pressure or severity of conditions—high rating or high silica—requires the phosphate in preference to the carbonate equilibrium. Under these conditions, magnesium usually combines with silica, mainly, to form magnesium silicate in sludge form; sometimes with phosphate or hydroxide to some extent. When the full phosphate equilibrium is maintained in the boiler water, calcium unites with phosphate to form sludge, and does not form deposits of calcium sulphate or silicate, even though the boiler water may be relatively high in sulphate and silica. Likewise, with blowdown holding total solids in the boiler water down to the 1500-3500 p.p.m. (quite commonly the former or less) which modern practice tolerates, and so long as the circulation keeps all boiler surfaces well wetted, the sodium salts which constitute the major portion of the dissolved solids, will not form deposits.

Dispersion of Sludge

At times, it is essential to take additional measures that the sludge in the boiler water shall remain in suspension to be removed by blowdown. Sometimes this may be effected by carrying higher alkalinity in the boiler water. At others, it may be advisable to make use of the dispersive action on the sludge of some one of the tannins or lignins, thus better keeping it finely divided and in suspension.

At times, especially in the low-pressure boilers of older design, when carryover occurs because of a difficult remediable contamination or other reasons, which cannot be corrected without more expense than the plant justifies, it may be convenient to resort to slight undertreatment, whereupon the calcium remaining in the boiler water combines with the soluble soapy impurities and thus removes them as insoluble calcium soaps, while the dispersive action of tannin or lignin keeps them well dispersed.

The Silica Problem

Even with full maintenance of the phosphate equilibrium, however, and with high or low concentration of silica in the boiler water, sodium-aluminum-silicate or silica scale may form at points where the surfaces are not sufficiently continuously wetted. Sodium phosphate, sulphate, and silicate, are frequently associated therewith. No treatment of the water—chemical or colloidal—can possibly eradicate these effects, which must be obviated by more continuous wetting of the surfaces, whether this may involve changes to relieve flame impingement, better steam-relieving capacity of the evaporative section, limitation of excessive operating rates, or some other one of several factors which may contribute to the

*From a paper presented before the Engineers Society of Western Pennsylvania.

condition. Also, when the steam is contaminated by boiler water, deposits of sodium silicate or silica may form on the turbine blading—usually silica when the steam contains appreciable carbon dioxide; sodium silicate when it does not.

Equipment and methods are available which will effect considerable reduction of silica concentration in the feedwater, and hence in the boiler water as well. Difficulty of removal increases rapidly with extent of removal, a residual of 10 p.p.m. being much simpler of attainment than one of 2 p.p.m. or even 5 p.p.m., as shown in the chart. Cost, which may easily represent a considerable or even major proportion of the entire expenditure for water treatment, since silica removal is not inexpensive, likewise rises rapidly per unit of silica removed as anything approaching complete removal is attained.

What Removal is Justified

When, and to what extent, can removal of silica be justified?

Every boiler water we have ever examined contained some silica. Undesirable in the main, it is beneficial from the standpoint of removing magnesium as magnesium-silicate sludge. With phosphate fully maintained, calcium-silicate scale cannot form.

On the other hand, if the surfaces are not sufficiently continuously wetted, sodium-aluminum-silicate will form, more rapidly to be sure if silica concentration is high, but none the less certainly if silica is low. In this case, then, silica-removal treatment of the feedwater is a palliative, but the basic remedy, as pointed out above, is to put an end to the condition of insufficient wetting of surfaces by adjustments of the boiler.

Table I. Silica Containing Waters

Water	R	M
pH Value	7.9	6.4
Analysis	**P.P.M.**	**P.P.M.**
Bicarbonate (HCO_3)	431	37
Sulphate (SO_4)	1	9
Chloride (Cl)	173	2
Silica (SiO_2) Gravimetric		
On Shaken Sample	31.2	–
On Filtered Sample	17.8	69
Iron (Fe)	0.3	0.9
Aluminum (Al)	trace	–
Calcium (Ca)	6.0	–
Magnesium (Mg)	1.9	–
Sodium (Na)	266	15
Dissolved Solids	678	124
Suspended Solids	28	8–10
Hardness as $CaCO_3$	23	10

When carryover of boiler water in steam occurs, deposits of silica or sodium silicate may form on the turbine blading, more rapidly if silica in the boiler water is high, less rapidly, but just as definitely, if silica is low. An exception is sufficient carryover to provide continuous washing of the turbine. Again, silica-removal treatment of the feedwater is a palliative, but the basic remedy is establishment in the steam-off-take drum of those conditions which inhibit carryover, whether by steam separators or washers, baffles, greater area in the tubes delivering steam to the drum, adjustment of water level, increment of blowdown, or by other means which promote the separation of boiler water from the steam before its discharge from that drum.

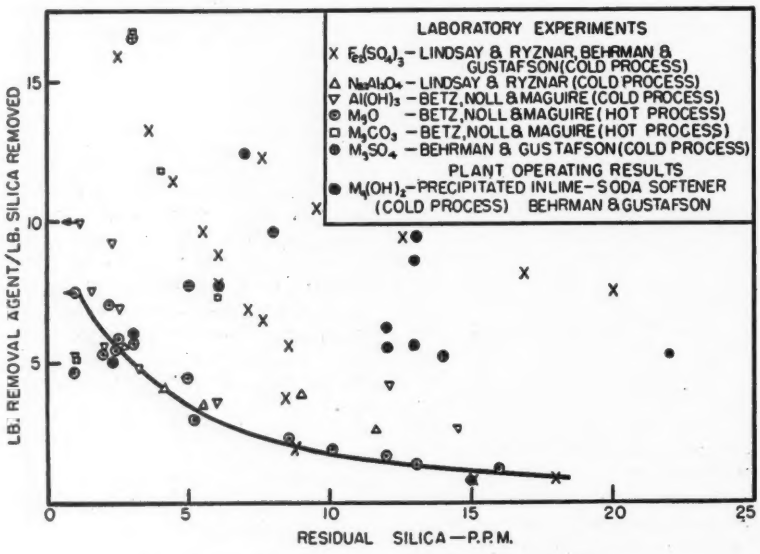
Quite obviously, merely decreasing silica concentration is not an "open sesame" to a paradise of freedom from boiler or turbine troubles arising from its presence in the boiler water. With or without the special treatment for silica, equal need will exist for exact control of conditions in the boiler water; need as well for sufficient blowdown to hold the concentration of silica and of other components in the boiler water within the limits recognized as good practice; and need for any adjustments to the boiler required to provide sufficient wetting of surfaces and separation of steam from boiler water.

In some cases, the expense of complete removal of silica from the feedwater may be justified. The lower cost of partial removal may be justified more frequently. In other cases, no need may exist for any special procedure for silica. Every case must be given individual consideration, and procedure defined in the light of the many other factors of operation.

Examples

1. Analysis M of Table I represents a water available for a plant which will operate at 450 lb. per sq. in. with total make-up. R is the analysis of water for a plant of similar pressure, but with only 50 per cent make-up. Both waters are high in silica. Any external treatment of M for the removal of hardness, is obviously unnecessary; but will be very advantageous—in fact, practically a necessity—for removal of the silica. This treatment, by providing filtration, will remove the 8-10 p.p.m. of suspended solids also, but must be operated with special attention not to increase the hardness or the total solids of the water any more than absolutely necessary. Since the total solids are low, blowdown will not be high, and hence it will be well that silica reduction be effected to leave perhaps not more than 7-10 p.p.m. thereof in the effluent water from the process.

2. Water R requires external treatment, not so much for reduction of hardness as for decreasing its dissolved solids and eliminating sodium bicarbonate and suspended solids. Thus, external treatment involves filtration, and passage of the water through a hydrogen and sodium zeolite com-


LABORATORY EXPERIMENTS
× $Fe_2(SO_4)_3$ – LINDSAY & RYZNAR, BEHRMAN & GUSTAFSON (COLD PROCESS)
△ $Na_2Al_2O_4$ – LINDSAY & RYZNAR (COLD PROCESS)
▽ $Al(OH)_3$ – BETZ, NOLL & MAGUIRE (COLD PROCESS)
⊛ M_gO – BETZ, NOLL & MAGUIRE (HOT PROCESS)
□ M_gCO_3 – BETZ, NOLL & MAGUIRE (HOT PROCESS)
● M_gSO_4 – BEHRMAN & GUSTAFSON (COLD PROCESS)
PLANT OPERATING RESULTS
● $M_g(OH)_2$ – PRECIPITATED IN LIME–SODA SOFTENER (COLD PROCESS) BEHRMAN & GUSTAFSON
LB. REMOVAL AGENT/LB. SILICA REMOVED
RESIDUAL SILICA—P.P.M.
0
5
10
15
20
25

Laboratory data on the removal of silica by various reagents

bination whereupon total dissolved solids will decrease to approximately 300 p.p.m. Silica of approximately 18 p.p.m. remains. Blowdown on the boiler, based on the treated make-up, must be from 15 to 20 per cent. This means that without any special treatment for its removal the boiler water may contain as a maximum between 90-120 p.p.m. of silica. Since, however, some of this will be lost by combination with naturally occurring magnesium, dissolved silica in the boiler water will probably run somewhat less than 100 p.p.m. With fully maintained phosphate equilibrium in the boiler water, this represents no difficulty, and leads to the decision that no special procedure for external reduction of silica concentration can be justified.

3. In this example, operating pressure is 450 lb. per sq. in. make-up between 40-50 per cent, and the lime-soda treated make-up water contains 20-25 p.p.m. of silica and 130-140 p.p.m. total dissolved solids. Trouble developed from scale which formed on the steam generating tubes, especially the bottom

Table II. Scale from Bottom Row of Generating Tubes

Substance	Per Cent	
Water Soluble		
Sodium Carbonate [Na_2CO_3]	6.0	
Sodium Hydroxide [NaOH]	0.8	
Sodium Chloride [NaCl]	0.9	
Sodium Sulphate [Na_2SO_4]	10.1	
Sodium Phosphate [Na_3PO_4]	21.9	
Sodium Silicate [Na_2SiO_3]	negligible	
		39.7
Water Insoluble		
Calcium Phosphate [$Ca_3(PO_4)_2$]	21.0	
Calcium Hydroxide [$Ca(OH)_2$]	0.9	
Magnesium Silicate [$MgSiO_3$]	2.3	
Sodium Silicate [Na_2SiO_3]	0.5	
Sodium Aluminum Silicate [$Na_2SiO_3.Al_2(SiO_3)_3$]	19.2	
Aluminum Oxide [Al_2O_3]	0.8	
Ferric Oxide [Fe_2O_3]	6.5	
Copper [Cu]	8.4	
		59.6
Total	99.3	

row. Its composition is given in Table II.

It is obvious from its composition of 39.7 per cent of water soluble salts and 19.2 per cent of

Table III. Turbine Deposits Forming with and without CO_2 in the Steam

With CO_2 present. Deposit on 5th wheel.	Per Cent
Sodium Chloride (NaCl)	8.7
Sodium Sulphate (Na_2SO_4)	3.9
Silica (SiO_2)	78.6
With CO_2 absent or negligible. Deposits found on 3rd to 15th row of reaction blades.	Per Cent
Sodium Carbonate (Na_2CO_3)	10.1
Sodium Silicate (Na_2SiO_3)	82.6

sodium - aluminum - silicate, that this scale developed because of over-working the steam generating tubes in which it formed. The question that must be answered is: Will external treatment to reduce silica in the make-up water prevent this formation sufficiently to eliminate the trouble? The question of maintenance of the necessary phosphate equilibrium need not be considered, since it is carefully maintained. Even if the cost of silica reduction in the feedwater is considerable, it would be justifiable if it would effect the desired result.

The answer to this question is readily evident from the fact that other boilers in the same plant, but not subjected to so high a rating, develop no scale under exactly the same water conditions. Therefore, while treatment to remove silica is not undesirable, the full solution of the problem cannot be obtained thereby, but requires either lowering the heat absorption of these over-worked tubes by shielding, or by instituting sufficient increment of circulation through them.

4. Table III shows the composition of turbine deposits, one, when appreciable carbon dioxide was present in the steam, and the other, in its absence, or its presence in only negligible quantity. In the first case, removal of the deposit means sandblasting or extremely difficult acid treatment, while in the latter, the deposit is readily removable by washing with saturated steam.

Conclusion

Why this difference? When carbon dioxide is present in the steam, it reacts with sodium silicate deposited in the turbine, uniting with the sodium and leaving silica. When an acidic material such as carbon dioxide is not present, the deposit remains as sodium silicate.

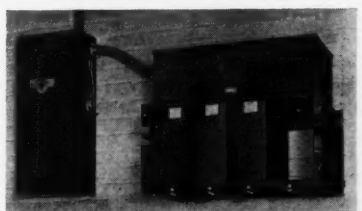
The desirable thing naturally is prevention of the carryover which results in the deposit formation. At least, however, if silicate deposit forms, it can be held to the form of sodium silicate which is easily removable by turbine washing. This is accomplished by minimizing the carbon dioxide content of the steam through careful choice and manipulation of the feedwater treatment.

Just as in problems of arithmetic, in problems of boiler water conditioning likewise the right answer depends upon the correct use of a few fundamental rules. When the necessary data on any problem have been made available by plant and laboratory, correct diagnosis of the problem follows, and leads to a logical decision on remedial procedure which is most economical both in time and money.

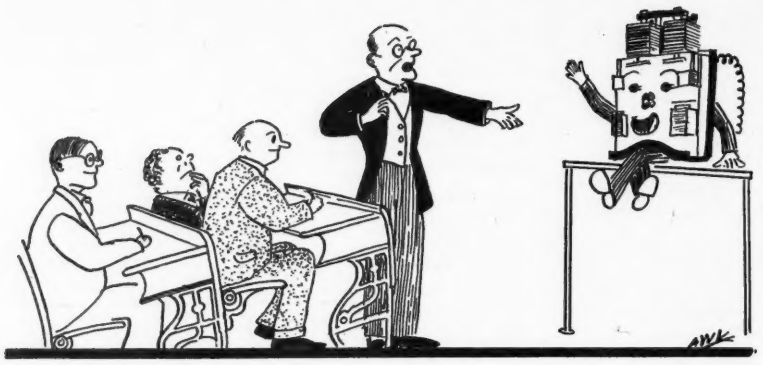
CAPACITORS SAVE ON POWER BILL

CAPACITORS, placed at the electrical distribution centers, have reduced monthly power bills of the Iron Fireman Co. plant in Cleveland, Ohio by 6 percent. Dust-tight Westinghouse units totaling 157½ kv-a., they have raised the operating power factor from 70 per cent to a near unity value of 97 per cent; and have released valuable extra feeder capacity that formerly was unavailable because of useless wattless current.

Stokers are manufactured at this plant, and the main electrical load consists of machine tools. The inherent low load factor of the driving motors created a low power factor condition that was responsible for an excess power demand charge. Cost of installing the total 157½ kv-a. of capacitors was approximately $2850. They have been in service 9 mo. Based on the average 6 per cent monthly savings, the installation will pay for itself in approximately 36 mo.



Connected through its safety switch to a wall mounted distribution panel above it, this capacitor is one of a number totalling in all 157½ kv-a., installed at the Cleveland plant of the Iron Fireman Co. Representing an investment of $2850, they have resulted in a saving of six per cent on monthly power bills, and will pay for themselves in 36 mo.



Things You Should Know About VOLTAGE REGULATORS

By F. E. CREVER
Generator-Voltage Regulator Engineering Dept.
General Electric Company.

EXTREME reliability has long been one of the prime requirements of important central station apparatus. Voltage regulators are no exception to this requirement as the proper control of machine excitation is one of the most vital functions in power generation. Until the beginning of the last decade vibrating regulators were used almost exclusively because other suitable types were not generally available. The vibrating types performed well, but were lacking in the fundamental reliability requirement as their contacts required periodic adjustment and replacement and the adjustments were not, generally, well understood. Today the situation is very much improved through the introduction and widespread use of rheostatic types of regulators, both direct and indirect acting.

Indirect-acting rheostatic regulators are those in which the voltage sensitive element actuates directly a variable resistance. The variable resistance is similar in action to a rheostat and is usually connected in the field of a self-exciter so as to directly control the alternator excitation through the medium of the exciter. A typical indirect-acting regulator installation is illustrated in Fig. 1. This is an extremely simple system wherein the a.c. voltage is rectified to furnish power for operation of a torque motor which in turn actuates a rheostatic element to control a self-excited exciter. Maintenance is practically eliminated and the system has proved to be highly satisfactory. A vital factor in the highly satisfactory record of this system has been the practice of using a regulator and exciter for each a.c. generator. This practice is called the "unit-exciter system" and it eliminates many of the hazards of operation prevailing previously where one vibrating regulator was used to control more than one exciter on a.c. generators operating in parallel. With the "unit-exciter system" each generator can be placed into or taken out of service very simply and easily without exciter or regulator switching as the regulator and exciter simply act to hold voltage at the generator terminals whenever the generator is running, regardless of whether it is connected to the bus or not. With a.c. generators, operating in parallel, compensation is provided for each unit for proper division of reactive kv-a. between a.c. generators. The reliability of regulators of this type and the fact that frequent maintenance is not required has led to the frequent practice of mounting regulators inside of switchgear cubicles.

There Weren't Any

A rather humorous incident arose from this practice. One of my associates visited such an installation and when he inquired about the regulators, he was told there weren't any. They had been mounted out of sight and their trouble-free operation had kept them out of mind.

Regulators of this type are recommended where they can handle the exciter field requirements directly. On larger units where the exciter field currents are greater, present practice is to use indirect-acting rheostatic regulators.

Indirect-acting rheostatic regulators are those in which a voltage-sensitive element controls the exciter field rheostat through the medium of an external mechanism. Usually the exciter field rheostat is motor operated and controlled by contacts from the voltage-sensitive element. A typical regulating system of this type is illustrated in Fig. 2. The exciter is separately excited from a pilot exciter which operates at constant voltage. The exciter field is controlled by a bridge type of motor-operated rheostat which gives smooth control of the exciter voltage for load changes which do not cause momentary

voltage fluctuations in excess of 5 per cent. Larger fluctuations engage an additional set of contacts to operate high-speed contactors to quickly raise or lower the excitation as required until such time as the motor-operated rheostat has run to such a position as returns the a.c. voltage within 5 per cent of normal. Operation of the high-speed contactors then ceases and the remaining correction takes place by operation of the rheostat alone. Overshooting or hunting is prevented by intermittent operation of the rheostat when the voltage has returned to within 2 per cent to 3 per cent of normal. The length of time the rheostat is operated is proportional to the deviation of the voltage from normal. In the case Illustrated this action is obtained by the use of motor-driven cam contacts. Other schemes are in use which result in the same action.

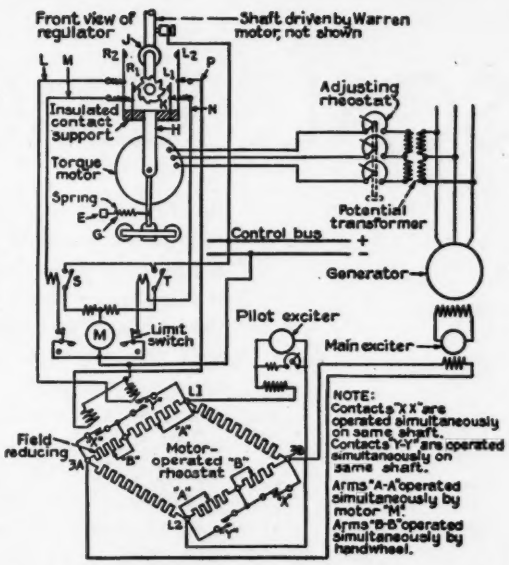


Fig. 2. Diagram of an indirect type voltage regulating system

Why Pilot Exciters?

The use of the pilot exciter is recommended as it provides more uniform response and makes the system applicable without special exciter design for stabilization of the exciter. With stabilized exciters the rheostat may be a series rheostat in the exciter field. Experience has shown the use of the pilot exciter to be more satisfactory as it provides more uniform response over the excitation range without resorting to special exciter design. Here again the "unit-exciter system" is recommended as giving most simple and reliable operation.

The rheostatic regulators described above give very reliable service and admirably meet the requirements of modern central station service. As a consequence the vibrating types have become for the most part obsolete. Other types of regulators have had some application, namely electronic regulators and static types. The electronic regulators can be made to give excellent operation and seem most applicable at present where precise regulation is desirable and where failure of tubes or circuit elements is not extremely hazardous. Static regulators consist of circuit elements which control the voltage without moving parts. Special exciters are often required for their use. Generally they are not sufficiently accurate for central station service. Their chief application has been to small portable generators where precise regulation is not required and where the equipment must stand a certain amount of mechanical shock and abuse that would be injurious to regulators with moving mechanical parts.

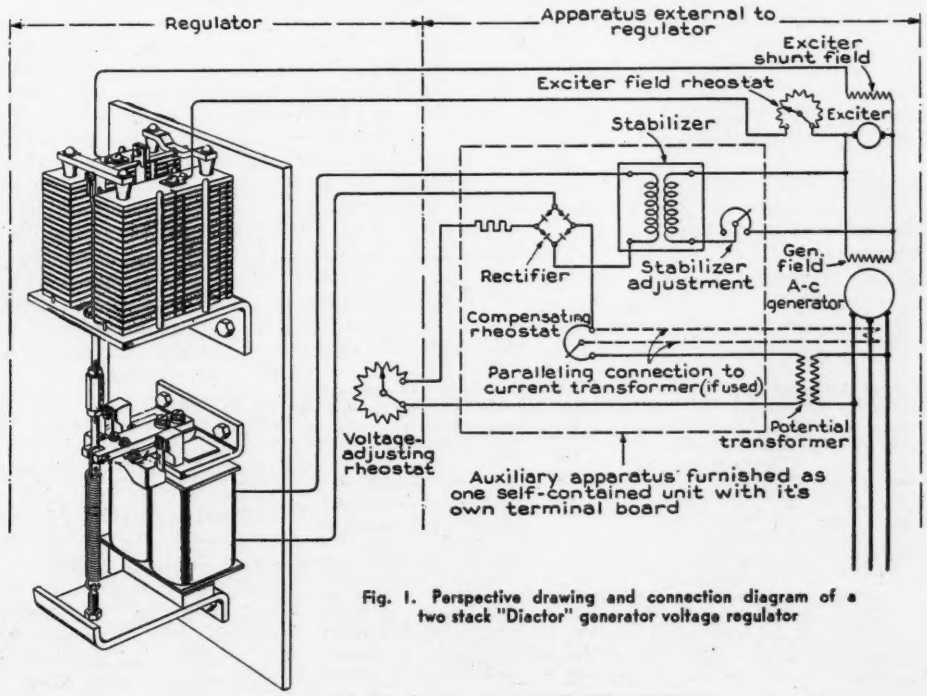


Fig. 1. Perspective drawing and connection diagram of a two stack "Diactor" generator voltage regulator

SCALE REMOVAL BY ACID

Acid offers a simple and effective method of removing scale from condenser and heat exchanger surfaces. It does, however, involve a potential hazard to both workmen and equipment which makes it imperative to carry on the work under careful supervision and then only after careful preliminary investigation to determine the kind and strength of acid which will remove the scale without serious damage to the metals. From a background of practical experience, the author outlines the important points to be considered, and then proceeds step by step through a typical condenser cleaning job from the preliminary test work through the selection of the acid, calculation of probable metal losses and cost comparisons, the actual cleaning and control of acid strength. A condenser with 7280 tubes, 22 ft. long, was cleaned in 4 hr. at a cost of $1052

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WHILE ACID has been extensively employed for cleaning mechanical equipment, technical information on the procedure is meagre. From our many experiences we have found it important that the following items be thoroughly analyzed before any acid treatment is justifiable:

1. The type of scale present.
2. The quantity of scale present.
3. A suitable solvent for the removal of the scale.
4. The quantity of solvent necessary for complete removal of the scale.
5. The maximum time required for the removal of the scale.
6. The maximum effect of the solvent on the metal of the equipment during the maximum time that is required to remove all of the scale.
7. The cost of the necessary equipment and chemicals to do the job.
8. The savings that can be derived by doing the job.

All of these are discussed in detail in this article in such a fashion that it should not be difficult for an engineer to follow the procedure easily. It is shown that only a small excess quantity of the free acid is necessary in the solution so that the reaction can take place. Furthermore this excess quantity should be carefully controlled throughout the entire cleaning procedure; first, for preventing a loss by using unnecessary and excessive amounts of the acid; and second, to avoid unnecessary reaction of the acid on the scale-free equipment.

Our research has shown that even the usual fibre and lead packings, that are sometimes used in sealing the tubes to the tube sheets, are not affected in any way by being in contact with a weak muriatic solution (2 to 3 per cent by weight of HCl) at room temperature, for periods as long as 4 hr. Thus, with careful and adequate control of the acid treatment, no harmful results, even to the packing, should follow. Specifically,

$$Pb + \text{dil. } HCl = PbCl_2$$

The $PbCl_2$ precipitate is insoluble in cold water and acts as a protective coating. Again,

$(C_6H_{10}O_5)$ (cellulose) + cool (room temperature) dilute HCl = No reaction.

For purposes of illustration, with specific data, application of the above principles to an actual condenser cleaning job is considered below in detail. This is the No. 2 condenser of the Dallas Steam Electric Station of the Dallas Power & Light Co., a two-pass divided water box condenser with 7280 tubes, 1 in. O.D., 18 B.W.G., 22 ft. 7/8 in. long, giving a total outside tube surface of 39,500 sq. ft.

Because of previous unsuccessful attempts to remove scale from

Table I. Metal losses calculated from laboratory tests. Although it is safe to assume that the copper losses in the last samples could have been reduced approximately one-half by using the low surface tension mercaptan inhibitor, the copper losses were so small that this was not worth while. Copper losses were so small that reduction of acid strength during the tests was negligible

Acid Sample No.	Contact Time With Tubes in Hr.	Cu. in gm.	Zn. in gm.	Cu. in gm. per 100 c.c. of solution	Loss of Cu. in gm. per sq. ft. of tube surface
1	2	0.00392	Negligible	0.0105	0.056
2	4	0.00644	Negligible	0.0174	0.093
3	2	0.00700	Negligible	0.0187	0.101
4	4	0.01322	Negligible	0.0352	0.190
5	2	0.00812	Negligible	0.0216	0.117
6	4	0.01372	Negligible	0.0366	0.198

Table II. Three samples of scale analyzed by use of a Shiebler Calcimeter showed the $CaCO_3$ to vary from 87.5 to 100 per cent

Sample No.	Type of Scale	Per Cent $CaCO_3$
1	Soft white	100
2	Hard black	90
3	Hard black	87.5

the water side of the tubes by turbining, an acid treatment for removal of such scale was employed. This treatment proved to be highly successful in removing all scale with a minimum loss of copper from the Admiralty metal tubes and tube sheets.

Before acid treatment was administered the effects of various acids were tested for: the effect on clean Admiralty metal condenser tubes; and the effectiveness in removal of the existing scale.

Effect of acids on clean Admiralty metal condenser tubes was determined by tests on six samples. Acid strength in each case was 15 per cent by volume. Samples Nos. 1 and 2 were placed in a muriatic acid solution of low surface tension with mercaptan[1] added as a Fe inhibitor. Samples Nos. 3 and 4 were placed in a muriatic solution of high surface tension with mercaptan[1] added as a Fe inhibitor.

Table III. Data for No. 2 condenser of the Dallas Steam Electric Station used in the article as a case study

Tubes (rolled ends) to be cleaned in condenser, No.	7,000
Length of tubes, ft.	22
Maximum weight of scale in tubes, lb.	6,160
Estimated weight of scale in water boxes, lb.	240
Max. estimated weight of scale in condenser, lb.	6,400
Max. estimated volume of 18 Bé muriatic acid necessary for dissolving all scale (170 carboys), gal.	2,040
Water capacity of condenser, gal.	9,600
Theoretically estimated strength of acid necessary in removal of total scale in condenser:	
18 Bé by volume—%	21
by weight—%	5.88

the results are tabulated in Table I.

From above tests it was concluded that the sample of acid having "low surface" tension would be the best acid, as far as harmful effects to tubes are concerned, for the removal of scale from condenser tubes. However, any of the acids tested could be used with safety as the maximum amount of metal removed by treatment would be negligible. The maximum amount of metal that would be removed from the entire condenser (7280 tubes) after a 4 hr. cleaning period with an acid, based on Sample No. 6, would be approximately 14 lb. copper and a negligible amount of zinc.

Table IV. Summary of estimated and actual data on acid use, scale and iron removal. Physical data on the condenser is given in Table III and the $CaCO_3$ content of the scale varied from 87.5 to 100 per cent as shown by Table II. Well and city water was used for dilution, in both the total carbonate alkalinity (as $CaCO_3$) is about 20 p.p.m.

	Estimated	Actual
Acid used—gal.	2,040	1,332
Acid soluble scale removed[2], lb.	6,400	3,875
Copper removed[2], lb.	14	13.05
Iron and zinc removed, lb.	Negligible	Negligible
Total acid cleaning time, hr.	4	4.25

Samples Nos. 5 and 6 were placed in an acid solution made from chemically pure HCl, but with no inhibitor added.

Tube samples were six pieces of old Admiralty metal tubing (0.8 in. I.D.) cut lengthwise. The tube, removed from No. 2 condenser, was cut into 4 in. lengths and each split lengthwise. They were thoroughly cleaned and polished so that entire surface could be reacted upon by acid solution. Each piece of tubing was placed in a glass cylinder and acid added to barely cover the tube sample.

Sample Nos. 1, 3 and 5 were allowed to remain in the acid solution for 2 hr. Sample Nos. 2, 4 and 6 were allowed to remain in acid solutions for 4 hr. At the end of the respective periods, each of the acid solutions was tested for quantity of zinc and copper present and

Various strengths of 18 Bé muriatic acid solution ranging from 1 to 20 per cent by volume were experimented with in removal of scale from samples of condenser tubes. In all cases, where sufficient volume of acid solution was employed, all scale was completely removed from the tube.

An analysis of acid showed it to contain 0.005 per cent ferric iron. Since analysis of the acid after reaction with the tubes and scale was contemplated, it was necessary to analyze the acid for impurities. Since, from the resulting data the quantity of iron found in the used acid solution was not in excess of the iron added with the acid, it was concluded that the loss of iron by the acid treatment was negligible.

Three samples of scale were tested for the quantity of $CaCO_3$ present. These analyses, made by the use of a Shiebler's Calcimeter, rangd from 87.5 to 100 per cent $CaCO_3$ as shown in Table II.

Several pieces of condenser tubing, 6 in. in length, were weighed before and after scale removal. The average amount of scale found to be present in a 6 in. sample of tubing was about 0.02 lb. The tubing secured for test purposes was removed from the upper half of the condenser where scale deposit was heaviest and hardest to remove by turbining. The lower half of condenser was comparatively free from scale.

In determining the maximum

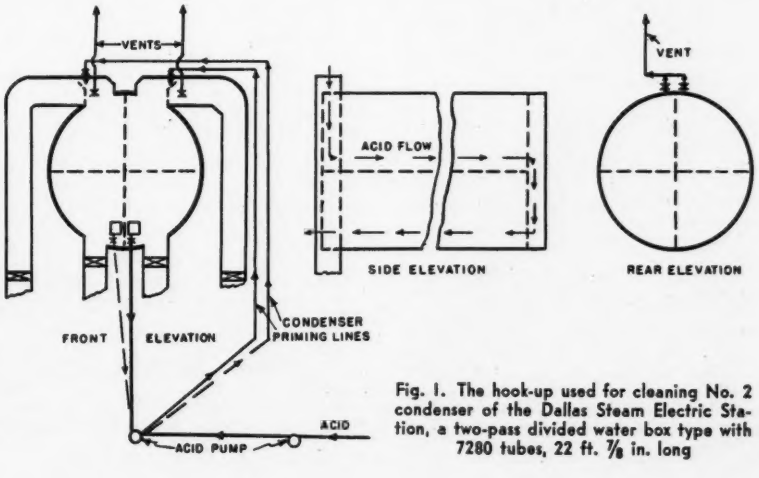


Fig. 1. The hook-up used for cleaning No. 2 condenser of the Dallas Steam Electric Station, a two-pass divided water box type with 7280 tubes, 22 ft. 7/8 in. long

[1]Mercaptan—any series of the general formula RSH analogous to the alcohols, specifically ethyl mercaptan C_2H_5SH, also called sulphur alcohol. Sample Nos. 1, 2, 3 and 4 were prepared by Dowell for test purposes and the quantity of inhibitor was not determined by the author.

[2]Previous tests showed that 0.33 per cent of the scale removed by turbining was copper filings so that in the removal of 3785 lb. of scale by this method 12.49 lb. of copper would be removed.

Table V. Cost of cleaning the 7280 tube condenser with acid. All scale was removed with negligible damage to tubes, tube sheets, etc.

Acid	$ 219.50
Other Material	218.17
Labor	614 95
Total Cost	$1052.62

quantity of 18 Bé muriatic acid necessary to remove all scale from the condenser, it was assumed that all tubes contained an equal amount of scale as represented by tubes containing the heaviest deposit of scale, i.e. 0.02 lb. per 6 in. of length or about 0.88 lb. per 22 ft. tube.

Procedure used is well shown by Fig. 1. Vent lines were installed in both front and back of the condenser, extending up to turbine room floor and discharging into metal cans connected by means of rubber hose to drains in condenser pit. The cans were covered with rubber blankets to prevent effervescence from the condenser discharging on the floor.

The circulating pump discharge valves were closed and gates sealed with 20 lb. of paraffin. The baffles in the condenser discharge lines were extended so as to guide the acid solution into the condenser. Plugs in the horizontal baffle on the front side of the condenser water box were removed to prevent formation of gas pockets that might form, preventing the flow of acid solution through tubes next to the baffle.

While the valves on the pump discharge were sealed, those on the condenser discharge lines were not. The north valve as shown by Fig. 2 was open slightly at the beginning of the cleaning period as noted at the bottom of Table VI. This valve was closed, but continued to leak. The leg was then kept filled with water through a tap in order to prevent the loss of acid solution over and through the baffle, and hence through the leaky discharge valve to the spray pond. As it was, the mishap caused the loss of 10 carboys of acid and 20 min. time.

The bypass connecting the north and south halves of the condenser was removed and used for an acid vat. Valves were installed at openings in the lower portion of the water box where the bypass had been removed. A pump was installed to circulate the acid solution in the condenser; the suction coming from the bypass portals, the discharge being the condenser priming lines.

Because the acid solution circulating pump did not effectively pump raw acid from the vat into the condenser, the 11th stage drainer pump was used as a booster pump. Two rubber hoses, emerging from portals of the acid vat were connected to the suction of the booster pump. The condenser discharge valves were closed, vents opened and south half of the condenser half filled with water. The acid circulating pump was started and 41 carboys (492 gal.) of 18 Bé. were immediately pumped into the condenser. Since the acid pump could just about care for all acid that could be poured into the vat it was so arranged that two carboys of acid were simultaneously emptying into the vat while full carboys of acid were being made ready to replace the empties.

Immediately after the entrance of the first charge of acid to the condenser, a sample of the solution was taken from a sampling line by the acid circulating pump and tested for strength. As the water level in the condenser was increased (water being pumped from acid vat), samples of acid solution were tested periodically. If the acid concentration dropped rapidly, more acid was added. When the acid solution became relatively constant, (that is the drop in acid strength over a period of 1 hr. became negligible and the condenser being full of acid solution) the acid treatment was halted.

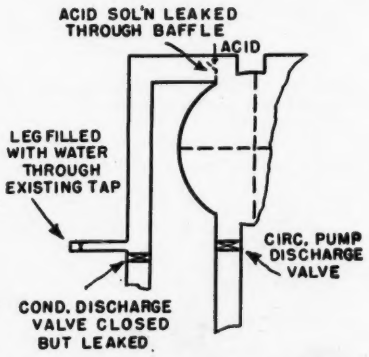

ACID SOL'N LEAKED THROUGH BAFFLE
ACID
LEG FILLED WITH WATER THROUGH EXISTING TAP
CIRC. PUMP DISCHARGE VALVE
COND. DISCHARGE VALVE CLOSED BUT LEAKED

Fig. 2. Sketch showing the leak mentioned in the remarks at the bottom of Table VI which accounted for the loss of 10 carboys of acid and 20 min. time

Table VI. Data sheet showing the progress of cleaning the two halves of the condenser. For an explanation of the remarks at the bottom of the table see the text. The leak increased the acid requirements 10 carboys and the cleaning time 20 min.

Time	Water in condenser	Acid carboys added	c.c. KOH per 100 c.c. sample	Per cent acid by weight	c.c. KCN per 100 c.c. sample	Grams Cu per 100 c.c.	Grams Fe(ic) per 100 c.c. sample	Pounds Cu Lost	Pounds Fe Lost
			SOUTH HALF						
1:30p	Half	41	12.2	2.65	1.9	0.00777			
1:50			12.4	2.70	..	.....			
2:10		51	11.0	2.40	5.4	0.02209			
2:30			9.4	2.05	4.2	0.01718			
2:45		61	8.3	1.80	6.3	0.02577			
3:00			9.7	2.10	5.5	0.02250			
4:10	Full		8.5	1.85	6.5	0.02659	0.0048		
Average for 4800 gal.								7.75	0.96
			NORTH HALF						
4:45	⅔	30	15.0	3.25	6.0	0.02454			
5:00	acid solu.		8.0	1.75	7.2	0.02945			
5:15	from south		7.5	1.63	5.2	0.02127			
5:30	half		6.0	1.30	4.0	0.01636			
5:35			5.2	1.15	8.7	0.03558			
6:00		10	4.6	1.00	9.2	0.03763			
6:10			5.2	1.15	..	.....			
6:15			6.3	1.38	7.7	0.03149			
6:30		10	5.6	1.23	5.4	0.02209			
6:50	Full		4.5	0.98	7.0	0.02863	0.0046		
Average for 4800 gal.								5.3	0.27

REMARKS: North condenser discharge valve was slightly open. Valve closed tight and line filled with water to top of condenser while acid circulation was in process.

Because the solution from this half of the condenser contained a reasonable quantity of free acid, two-thirds of it was pumped into the north half of the condenser and the remainder discharged into the creek. To the acid solution in the north half of the condenser, more 18 Bé acid was added. Tests for acid strength of solution were continued as before and procedure carried out as in the south half of condenser treatment.

At the end of the cleaning period, waste acid solution was discarded into the creek rather than into the alkaline spray pond water where a re-precipitation of the calcium scale would re-occur.

The average time for cleaning each half of condenser, that is from time the acid was first added to the time the condenser was drained, was approximately 2.5 hr. Ordinary house service (well and city water, room temperature) was used for acid dilution. Inspection of both halves of the condenser revealed that all tubes, tube sheets and water boxes were entirely free from scale and cleaned to metal.

Sample Analyses in Laboratory

All samples collected and tested for acid strength were taken later to the laboratory and quantitatively tested for copper. The loss of copper in the south half of the condenser was determined to be 7.75 lb. and in the north half, 5.3 lb. This was a total loss of 13.03 lb. as compared to an estimated 14 lb. The total loss of scale, as determined by acid used in the entire condenser was 3875 lb. as $CaCO_3$. The total amount of acid added to the entire condenser was 111 carboys or 1332 gal.; estimated, 170 carboys or 2040 gal. The total amount of acid actually used for scale removal was 1152 gal. The total amount of acid in excess and discarded with the acid solution to the creek was 280 gal.

Determination of the strength of the acid solution was made by titrating a 100 c.c. sample with KOH using phenolpthalein as an indicator. The determination of Cu was made by precipitating the Cu from a 100 c.c. sample as CuS, dissolving the precipitate with acid, adding NH_4OH to the copper ammonium hydroxide and titrating with a standard KCN solution. Curves were drawn to facilitate calculations for the strength of acid solution in the condenser and for conversion of carboys to gallons.

The rubber gloves and aprons were used by two men pouring acid. A strong solution of soda ash was prepared and kept available for neutralizing any acid spilled.

Table VII. Condenser performance before and after cleaning. The terminal difference in degrees F. is the temperature difference between the condensate leaving the hotwell and the cooling water leaving the condenser. The decrease in back pressure ranged from 0.15 to 0.20 in. of mercury

Turbine Load Kw.	Terminal Diff. Deg. F. Before Cleaning	After Cleaning	Decrease
15,000	10.0	3.5	6.5
20,000	10.6	5.1	5.5
31,000	15 2	7.5	7.7

Performance of Centrifugal Pump Packing

Part II. In the September issue the author dealt with the quantitative measurement of leakage; in this article he takes up the measurement of friction, the effects of reducing packing depth, of shaft vibration, of speed of shaft, of temperature and the spring loading of centrifugal pump shaft packing

BY F. C. THORN
Chief Chemist
Garlock Packing Co.

NOTHING was said about packing friction in the previous article[1], and in fact the friction readings were disappointing. For one thing, the measurement included the frictions of inboard bearings as well as packings. We attempted to correct for the friction of the bearings by running a short test without any packings in the boxes, the water escaping freely from the barrel ends. The bearing friction so determined constituted about 80 per cent of the normal combined frictions of bearings and packings; wherefore any corrected figures for packing friction must be regarded as highly unreliable. If we can believe the figures, running packing frictions under stable conditions are of the order of 0.3 lb. per circumferential inch per set, and not much influenced by the maximum permitted leakage. A difference was clearly seen, however, in the friction peaks attained immediately following each retightening. In the case of the packing operating at 10 c.c. tolerated leakage, which we regard as a normal tolerance for these conditions, the peaks did not exceed 1 lb. per circumferential inch. In the case of the "leakless" test, peaks of the order of 10 lb. per in. were recorded, which diminished rapidly as a slight leakage was restored. Furthermore, the "leakless" test was the only one which showed evidence of sleeve scoring at the conclusion of the test.

In the chart (Fig. 1) leakage was held at 10 c.c. per min. and the pressure increased to 50 p.s.i. and again to 100 p.s.i. These are shown in comparison with the 25 p.s.i. test reported in the September issue. It will be noted that higher pressures, leakage remaining constant, cause increased loss of volume, the effect being practically proportional to pressure. Even the 100 p.s.i. test, however, survived the 1000 hr. period in a stable condition, showing that a multiplication of the pressure by four does not have as profound an effect on packing life as a reduction in tolerated leakage from 10 c.c. per min. to nearly zero.

[1]See page 80 of the September issue.

Water Pressure and Packing Volume

In the next chart (Fig. 2) I show the effect of reducing packing depth to three rings and one ring respectively in comparison with the five ring test. Since these start from differing initial volumes it was necessary to reduce all volumes to percentages for comparison. It will be observed that volume loss is higher, as a percentage, in the case of the shallower sets. All tests survived the 1000 hr. period in stable condition, from which we conclude that even reducing the packing to a single ring is not as destructive in its effect upon packing life as an attempt to eliminate the small but necessary leakage.

It seemed that something might be done in the direction of combining the results of the last three tests. From purely theoretical grounds, and based upon analogy to other laws governing fluid flow, we might expect that leakage at any moment would be a linear function of pressure dif-

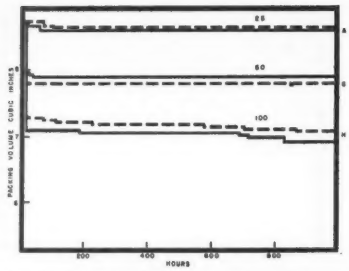


Fig. 1. Leakage held constant; water pressure and packing volume varied

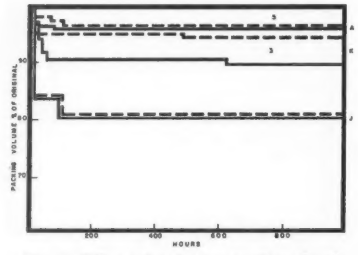


Fig. 2. Effect of reducing packing depth

ference, inverse function of depth and viscosity, and related in some way to clearance, or, mathematically:

$$L = \frac{P \times f(C)}{D \times \eta} \text{ or } f(C) = \frac{L \times D \times \eta}{P}$$

Or since η is constant (about 1 centipoise) for the whole series:

$$f(C) = \frac{LD}{P}$$

Now we have a very vague idea what we mean by clearance beneath a packing and it is probably not a single value, but a value which varies from point to point, but we have some conception of average clearance, which is what we mean when we say that a packing is tight or loose. Furthermore, we believe that tightness or looseness is the determining factor in packing life, which, if true, should make it possible to substitute some other index of packing life, such as for instance, volume loss in 1000 hr. in place of C without upsetting the truth of the equation. Likewise we have no figure for instantaneous, or even for average leakage, but we can assume that it is in someway related to maximum permitted leakage, we can substitute this value for L. Depth likewise varies all the time, but can be related to the initial depth, which can be expressed in terms of the number of rings. Let us now tabulate our previous results in order of volume loss at 1000 hr.

TEST	L	P	D	LD/P	LOSS-%
A	10	25	5	2.0	4.0
K	10	25	3	1.2	7.5
G	10	50	5	1.0	10.0
H	10	100	5	.5	18.0
E	2	25	5	.4	14.0
J	10	25	1	.4	18.5
D	½?	25	5	.1	28.5

It will be seen that changes in pressure, depth or leakage are, in themselves, erratic, but if all are reduced to the expression LD/P they line up very nicely with the volume loss, only one case of inversion being noted. When volume loss is plotted as a function of LD/P (Fig. 3) it will be seen that it makes a reasonably smooth curve. The assumption of ½ c.c. leak for Test D is, of course, purely an assumption; if the figure were set at zero, the effect would be merely to cause the curve to pass through point D[1], but I prefer to let the ½ c.c. figure stand to emphasize that truly leakless operation would result in even worse performance than Test D; in fact, in a volume loss so great that the test would be terminated in a comparatively few minutes. In fact, we have independent evidence that that is just what happens when an attempt is made to eliminate all leakage.

Too much importance should not be attached to Fig. 3 as a quantitative statement; it is obviously dependent upon a large number of assumptions, and there is no doubt that if we had employed a more fine-grained retightening procedure, so that the actual and maximum leakage would have more nearly coincided, we would have a different curve, presumably lying lower on the chart. Furthermore, the "law", even if true, has been proven for only a limited range of conditions and for this packing only. There is value, however, in the emphasis placed on the fraction LD/P because it brings to light certain facts which are not as widely appreciated as they should be. Almost any pump operator knows

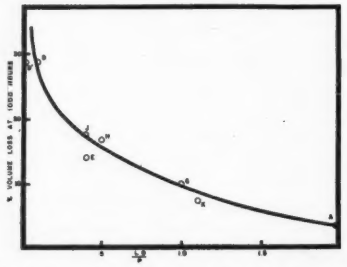


Fig. 3. Variation of packing volume loss with clearance

that packing performance is poorer as a result of doubling the fluid pressure or halving the packing depth,—but how many realize that the same effect results from halving the accepted leakage? How many have any real knowledge of what leakages they are getting, or make any effort to standardize this important factor?

There are other factors that influence volume loss, hence indirectly packing life, that do not lend themselves to mathematical treatment with equal facility. In the next chart (Fig. 4) I show the effect of substituting for the true-running shaft[2], one equipped with sleeves 0.005 in. off center, and 0.010 in. off center respectively, leakage remaining constant at 10 c.c. and all other factors standard.

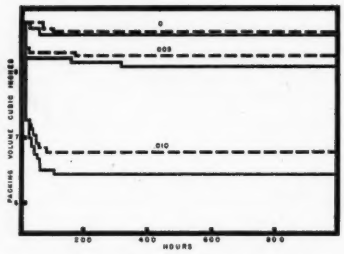


Fig. 4. Effect of vibrating shaft

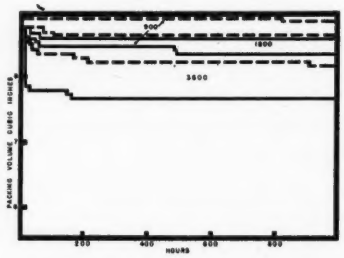


Fig. 5. Effect of shaft speed

It will be seen that the life is greatly shortened by shaft gyration. There is no doubt that the tendency for a gyrating shaft operating against a relatively inelastic packing is to batter out an opening larger than the shaft diameter, and tight adjustment is necessary to avoid a large increase in leakage under these conditions. It seems probable that if we had accepted a much larger leakage, we could have obtained satisfactory operation. Most engineers do not fully appreciate what worn bearings and unbalanced rotors can do to packing performance.

Figure 5 is designed to show the effect of speed. The indications are that with 10 c.c. leak on a true-run-

[2]See Fig. 4, page 81, September issue.

ning shaft, there is no important difference between 900 r.p.m. and 1800 r.p.m. At 3600 r.p.m. the volume loss is greater but not as great as one would be led to expect. All this follows from the fact that friction is reduced to a point where excessive local overheating does not occur at the speed employed.

The next chart (Fig. 6) shows the effect of an increase in temperature. The 212 deg. F. test might have survived 1000 hr. if continued, but its inferior performance is already evident. Hot water exerts several effects favorable and unfavorable. In the first place, it reduces the viscosity of the water, which means that more water escapes through the packing, other things being equal. In these tests we did not permit the leakage to increase to compensate for the reduced viscosity of the water, which means that we were forced to operate with a tighter packing. At 212 deg. F. a new effect enters; the water boils and escapes largely in the form of steam. This effect is probably favorable, because steam is not counted as a water-leak and more water actually leaked than was reported. It is probable that the results at 212 deg. F. would have been much worse than they were if a large part of the water leak had not flashed into steam and escaped being counted. The other unfavorable effect, however, is the thinning of the packing saturant with increased temperature, whereby its rate of escape from the stuffing box is increased. This effect can be counteracted to some extent by proper packing selection, providing ample leakage rates are maintained. Substitution of a relatively infusible binder under conditions of tight operation would, however, result in immediate seizure.

The worst possible effect is obtained when one tries to operate "leakless" with water at 212 deg. F. I do not show the log for this test, but what happened was that the packing failed completely in 64 hr. and was removed with pieces of the wear sleeve imbedded in it.

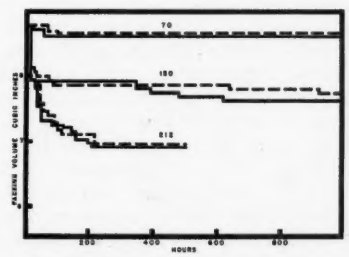


Fig. 6. Effect of temperature increase

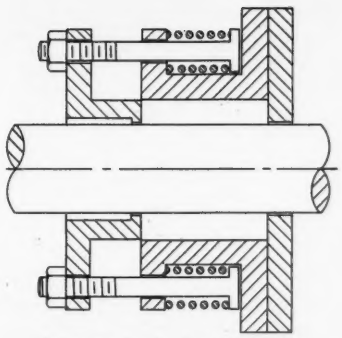


Fig. 7. Spring loaded stuffing box

We should not bother to mention this test if it were not for the fact that the same thing is being attempted all over the United States every day. This situation cannot be remedied by any sort of packing selection.

The key to long packing life on hot water service, as well as on cold water service, lies in provision for adequate leakage.

Many designers favor spring-loaded glands in preference to glands with rigid adjustment, probably on the theory that the springs hold the packing at a fairly constant clearance and hence fairly constant leakage rate. To test this theory out we modified the stuffing boxes as shown in Fig. 7. The springs correspond to the following description.

Length (in.)	Load per spring	Packing load (p.s.i.) for four springs
$1\frac{1}{4}$	none	none
$1\frac{3}{16}$	10	11
$1\frac{1}{8}$	19	22
$1\frac{1}{16}$	29	33
1	39	44
$\frac{15}{16}$	48	55

Packings were five-ring sets as before; conditions 25 p.s.i. cold water and speed 1800 r.p.m. The manner of operating was as follows:

(a) The springs were started at $1\frac{1}{16}$ in. length—this corresponding to a load of 33 p.s.i. of packing area, or only slightly in excess of the water pressure. (It was found that a unit packing load in excess of the water pressure was necessary to avoid heavy initial leakage.)

(b) Since volume loss in the packing caused a decrease in spring tension, the nuts were tightened as necessary to restore the spring tension. With longer springs this might not have been necessary.

(c) When the leakage exceeded 10 c.c. per min. the springs were tightened to 1 in. length (equivalent to 44 p.s.i. of packing area) and maintained at this length. If the leakage had again exceeded 10 c.c. per min., the springs would have been tightened to $1\frac{1}{16}$ in. length.

Log of test up to 600 hr. is shown in Fig. 8 compared with test under same conditions with rigid adjustment taken from Fig. 4, page 81 September issue. It will be noted that springs on both stuffing boxes were tightened once (to 44 p.s.i. equivalent) but not again for the full duration of the test. There were an additional five adjustments at each end to hold the spring at the assigned tension. These figures compare with an average of five adjustments at each gland under the rigid adjustment procedure. There would appear to be no economy in the matter of number of adjustments unless the springs were of a type which gave substantially the same load regardless of gland movement. Furthermore, the friction of the spring-loaded packing was

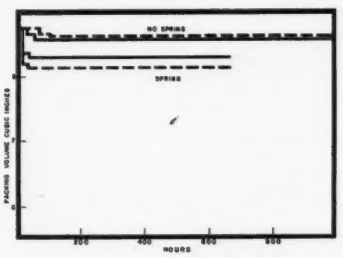
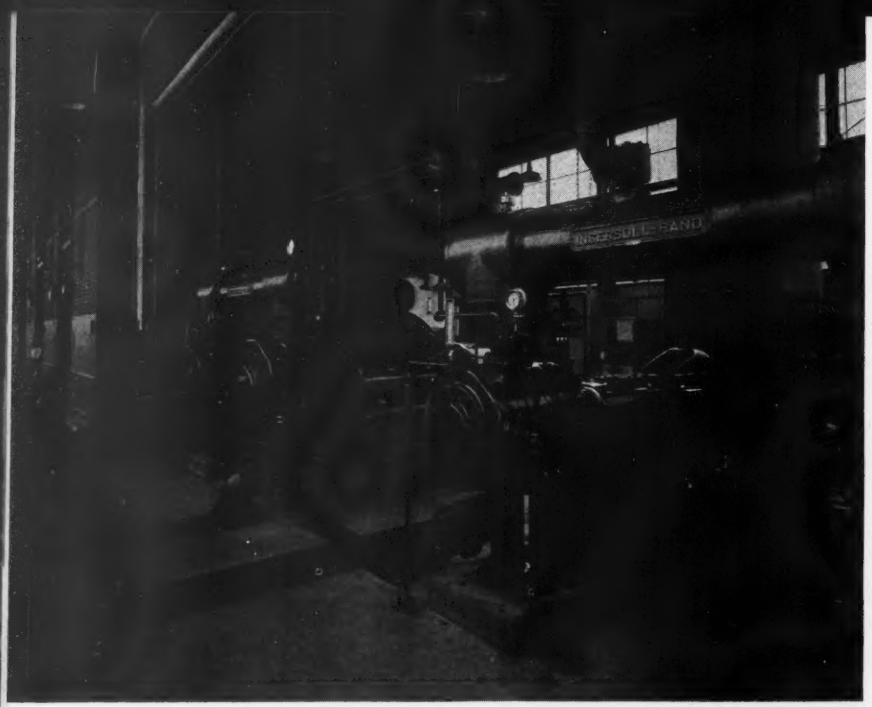


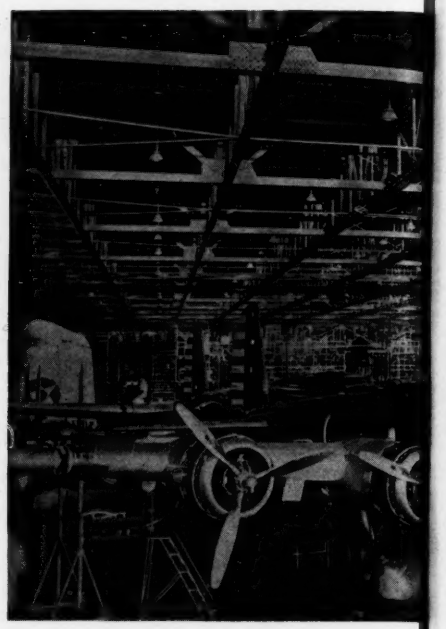
Fig. 8. Comparison of rigid adjustment and spring loading of stuffing boxes

higher, the volume loss was greater and a shorter life indicated.

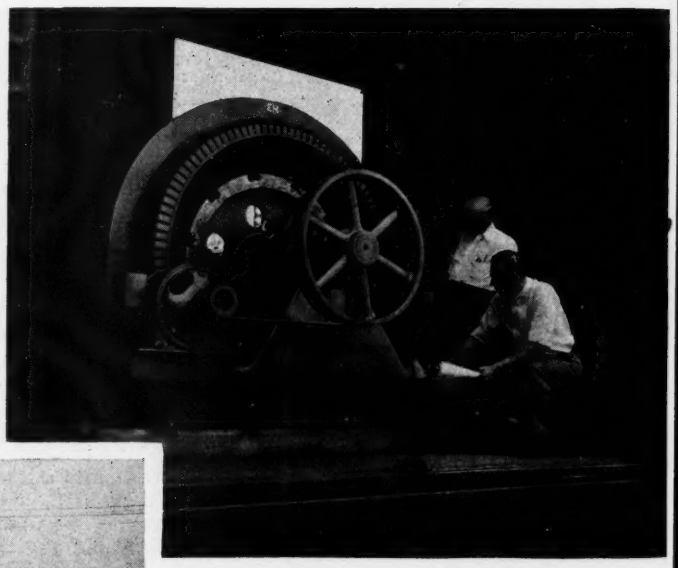
Comparison with the test under 10 c.c. permitted leakage, however, is unfair, since, except for the single instance when increased spring load was applied, the leakage at no time approached 10 c.c. per min. with the spring-loaded gland. For the most part, it ran at about 3 c.c. per min. If we compare with the 2 c.c. curve on Fig. 4, (page 81 September issue), which required 15 adjustments (average) at each end and lost 14 per cent of its original volume, the performance of the spring loaded stuffing box is seen to be superior. Summarizing, a spring-loaded stuffing box is seen to force the packing into at least partial contact with the shaft, which is all right where the conditions (surface speed, etc.) permit a low leakage rate. Providing the spring tension is carefully chosen, this arrangement is superior to rigid gland adjustment. Where the conditions demand a high leakage rate to avoid overheating, a spring gland is not indicated.

PICTURES

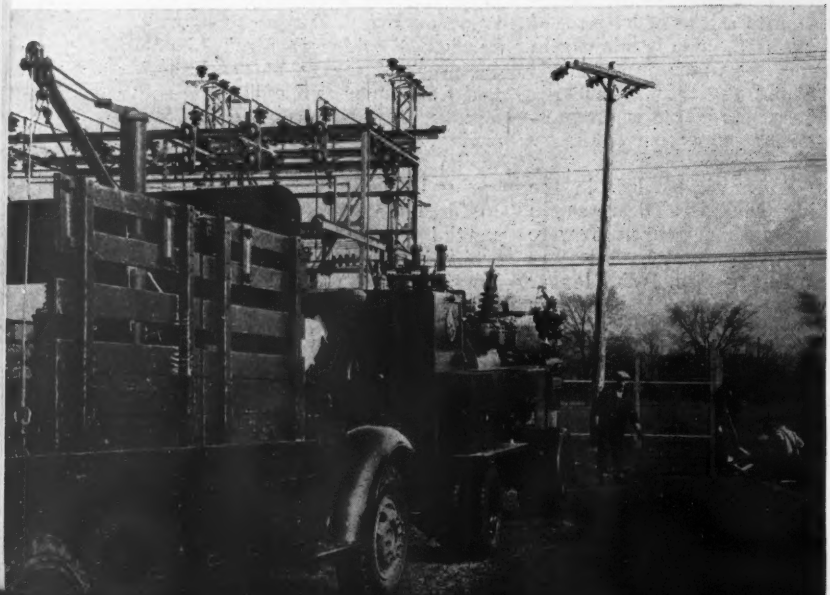




Defense and more defense. With the 41 acre bomber plant of the Boeing Aircraft Co. completed and in production at Seattle the Austin Co. has started construction of a new addition to Boeing's new bomber plant at Wichita, Kansas. Above is shown a view inside the boiler house which supplies heat and compressed air for the Seattle plant, while at the right an across the opposite page is a view looking across the smaller of two wide-span final assembly bays in the same plant. This view shows Flying Fortresses approaching completion. Monorail bridge cranes serve the entire area and fluorescent fixtures alternating with Mazda lamps provide a minimum of 20 ft. candles on the working plane.

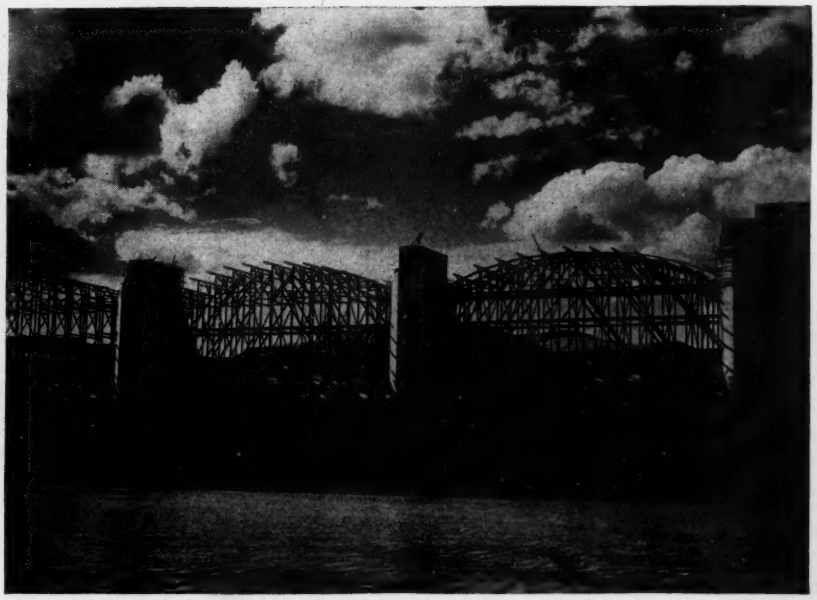


The Eastern oil shortage is one step nearer solution with the completion of the first two of ten synchronous motors being built by Electric Machinery Mfg. Co. to drive the pumps in the new crude oil pipe line now under construction between Portland, Maine, and Montreal, Canada. The view at the right shows the two motors being given their final inspection in the freight car before shipment.



To provide emergency power in places where shortages may develop a number of mobile substations have been constructed for use in various parts of the country. The view at the left shows one designed and manufactured by the General Electric Co. for the Central New York Power Corp. It is a 1000-kw. unit, and it is estimated that it can be hooked up to carry load in about 30 min. if necessary. The new unit was given its first job when it was hooked into service in Syracuse to relieve one of the substations of too heavy a load.

S of Engineering Interest



Three hundred and fifty feet above the Columbia River hardy Grand Coulee construction workers are erecting the false-work for 11 concrete bridges which will surmount the middle section of the 30 ft. highway surmounting the crest of the structure. The 11 spans, each 135 ft. long, will be seated directly over a waterfall twice as high as Niagara.

At the right is a photograph of a new anti-sabotage light for use in protective fence lighting systems. It is seen here on test in the General Electric Illuminating Engineering Laboratory at Schenectady, N. Y. The unit uses a Fresnel type heat-resisting lens to produce a wide horizontal spread of light and a relatively narrow vertical beam. The reflector for the unit is made of chromium plated copper. Lens and reflector are assembled into a sheet steel housing. The complete luminaire is available in series or multiple types for a maximum of 600 lumen series or 300-watt multiple lamps. A special bracket enables the unit to be adjusted in the horizontal and vertical planes.

REFRIGERATING ENGINEER

Part IX. You learn that floods can be dammed in more than one place and in more than one way, and that a flooding coil will make an operating engineer's finger stick to it as well as making the engineer stick to his job. You also find that a roof jack can be a handy tool to clean condenser tubes

By GEORGE HOLMAN

SIX DAYS YOU SHALL LABOR, and in the summer time, also the seventh. Having slept the clock around, you feel fit enough to kick the table over and start rough house. Today, you decide, you are going to run that plant, instead of letting it run you, as has been the case for the last 6 days.

You get to the plant early. At once you notice that there is frost on the manifold of the cooling room compressor, and that it runs much quieter than usual.

Andy says, "She started frosting back about an hour ago. I don't know what to make of it. One of the thermoexpansion valves must be opened too wide."

That is evident. After Andy leaves, you go into the storage and look around. Remembering what Frosty said about the temperature fall in the remote bulb causing the pressure to fall in both bulb and diaphragm chamber, you examine the location of each bulb. Each is tightly clamped to the return pipe of the coil it serves. A warm bulb holding its connected valve open cannot be the cause of the trouble. But Frosty also said that when the pressure in the bulb fell, a spring closed the valve. Maybe the spring on one of the valves is broken or gummed up with the same kind of oil you blew down from the accumulator. There are 21 valves on the cooling room system, one in each of the 14 coolers, 4 in the ice storage and 3 in the chill room. There would be 22 valves, had you not clipped the capillary tube on the one in No. 6 cooler, and taken one from the chill room to temporarily serve in its place.

Going back to the tank room, you find that the indicator on the cooling room accumulator is now frosted from top to bottom. After checking over the ice field to see that the air bubbles rise in the cans and assure good agitation while freezing, you go back to the machine room. The cooling room compressor is running so smoothly that it is only by watching the flywheel that you can tell that it is running at all. Now, why is that? Another poser for Frosty.

"Howdy, Mister!"

You jump as if a contactor on the switchboard has suddenly closed without warning. But your nerves end up with a very pleasant sensation. You swing joyfully about to face the window. No, you are not dreaming. It is really June . . . "Why, come right on in!" You fairly bubble over with delight.

"Hunnnhhn-unnnhhh!" June protests. "Daddy says I mustn't. He says I'll distract your mind from your work by coming here. But I don't think that I'm a bit disconcerting, do you?" she asks, and smiles that heavenly smile that makes your heart pound like a piston of a flooding compressor lifting a safety head.

From the outside June perches on the window sill. From the inside you do likewise. The window is not very wide. But you don't mind that at all. "Where'll we go tonight?" you boldly assume June's consent.

"Where will *we* go tonight?" June mocks. But you know that she is only teasing you. "That depends on Daddy. He came home last night."

Click - click - click - click. You have lost yourself in the deep blue of June's eyes when that warning sound comes from the cooling room compressor. You dash to the switchboard and switch the latch to neutral. But when you turn back to the window, June is waving, "Good-bye! See you at 7 o'clock."

You go into the tank room and shut the liquids off at the stop valve. Then you go back and start the compressor.

Help! Help!

At the end of a half hour the frost disappears from the manifold. You go into the tank room and open the stop valve slightly. You can pump out the accumulator again. But that will not remedy the trouble. You give up, and go to the telephone and call up Frosty. In 15 min. he arrives on the scene.

"I've got a flood in the cooling room system," you tell your visitor. "I feel sure that it started the other day. The oil was pretty low in the compressor crankcase. I decided to put some more oil on it. Well, when I first started, I blew what oil was in the crankcase out. Then I put this kind of oil in."

You indicate the can from which you charged your first oil into a compressor crankcase. There is still about a gallon of oil in it. Frosty looks at the oil, sticks a finger into it and holds his finger up to the light. "A compound oil," he muses. "And you had trouble with it in the machine?"

"Yes."

"How did it act?"

"It turned to a soapy sludge."

"And then you had to clean out the whole machine, eh?"

"Yes. But that was about 12 hr. later."

"A compound oil is not good for ammonia compressors," Frosty says. "Neither is an animal oil or a vegetable oil. If you don't know that the oil you are putting into a compressor crankcase is the right kind of oil, you are taking a big chance. A pure mineral oil is the thing. Vegetable, animal or compounded oils will form a soap with ammonia, as if the ammonia were lye. Lye and ammonia are both alkalies, and act and react alike. By putting a sample of a doubtful oil into a bottle with a few grains of lye, and then heating it somewhat, you can pretty near tell whether or not that particular oil will sludge up with ammonia. If on shaking after heating a soapy

scum forms on it, or if it changes in any other way, don't use it."

"But here is what is wrong now," you interrupt Frosty. "Night before last this compressor ran for quite awhile with the valves sticking open. The whole system flooded. I've tried pumping it out. But the coils and the accumulator always fill up again. I know that the flooding may be from any one of the 21 coils in operation; and I know that setting up the valve on that particular coil will stop the flooding. But how am I going to locate the valve that is causing the trouble?"

"That's a good question, and one that requires a bit of explaining to answer," Frosty replies. "Look up there at your suction gage. It shows 15 lb. pressure. With the compressor in operation, there may be a slight pressure drop in the return line between the coils and the place the gage taps in. But to illustrate the principle involved, we'll disregard that pressure drop, and assume that the pressure in the coils is also 15 lb. per sq. in. gage."

The Stick Test

"Now look at the red 15 opposite the 15 lb. pressure reading," Frosty continues. "It is zero. That means that any liquid ammonia lying in the system will have a temperature of about zero Fahrenheit. If there is any liquid ammonia coming back from a coil it will have a temperature of about zero. If those coils had a thermometer well in them somewhere near the return valve, we could test them that way and see. But seeing as how they have no wells, we must use the old stick test, a mighty handy rule of thumb in our case. This rule of thumb is a simple one. A wetted finger touched to any piece of metal having a temperature of less than 15 deg. above zero will stick or freeze to the metal. Some little effort will be required to pull the finger loose, as if it had glue on it."

"Now, if everything in a cooling room is at or below a temperature of 15 deg. above zero, as is the case with the freezer, your finger would stick to any piece of metal in the room, and certainly to any part of the coil which cools that room. But where rooms are held at temperatures above 25 deg. the return end of the coil will be warmer than the end of the expansion valve. If a coil consists of 500 or 600 ft. of pipe weaving back and forth in a room in which the air is 35 deg. in temperature, the temperature of the gas leaving the room will also approach the temperature, unless the gas is kept cooler by the constant evaporation of liquid ammonia throughout its travel through the coil."

"Now, let's try to figure this out," Frosty goes on. "Since this has just happened lately, my guess is that the flooding comes from the valve you changed from the chill room to No. 6. These valves may suddenly stop letting liquid into the coils, as when the power assembly loses its charge or the orifice clogs up. But usually they don't suddenly open up."

With Frosty beside you, you go into the storage and carry your stepladder about from room to room. Sure enough, on scraping the frost off a spot on the last pipe of the coil in No. 6 cooler, your wetted finger sticks to the bare metal. "Set the valve stem up three full turns," Frosty advises. "Then make a note of it. If three turns is too much, and the room temperature rises, you can open the valve a half-turn at a time. If your flooding continues, you may have to set the valve up more yet. Or, you may be compelled to place that valve in a room held at a temperature nearer that of the chill room, where you got it, and put another valve in its place. Those remote bulbs are sometimes charged with a specific substance which will correctly open the valve and allow the valve to close only within a certain temperature range of a few degrees."

Continuing on your rounds, you come to No. 9 cooler. There the thermoexpansion valve has frost all over it, and the liquid line is heavily frosted clear back to the first stop valve. Beyond that valve the line is lightly frosted. And at the return your wetted finger sticks. When you try to set up the thermoexpansion valve, you already find the stem set up to the limit. There isn't enough of the stem sticking out of the packing nut to get hold of with your pliers. Holding the stem shield in one hand and the pliers in the other, you look down at Frosty. "What's the matter with this one?" you ask.

"The answer to that one is simple," Frosty says. "The needle has been taken out of that thermoexpansion valve and that stop valve is being used as a hand expansion valve. The heavy frost on the stop valve betrays the spot where expansion and evaporation begins. The lighter frost farther back on the liquid line is due to the cooling of the liquid in passing through the accumulator."

The stop valve is almost closed, but not quite. "Close it tight," Frosty advises, "and let the liquid beyond it evaporate. After awhile, you can take it out of service for inspection, and possibly use one from the ice storage in its place, that is, if you can't find the needle."

You go back to the machine room. "That coil in No. 9 had been operating with the stop valve as an expansion valve for a long time," you comment to Frosty. "I'm sure that it hasn't been touched for the last week. I want to know why it wasn't flooding back to the accumulator before."

"Well, it's this way," Frosty is equal to the necessary explanation. "That that coil has been flooding back to the main gas return line for some time is evident. The reason that no liquid reached the accumulator was because it was evaporated by the warmer superheated gas from the other coils of the system. Instead of having a temperature of zero at 15 lb. gage pressure, the gas leaving those coils is at temperatures of 20, 30, or 40 deg. The liquid ammonia returning from No. 9 coil has been taking up heat from this gas in evaporating, and thereby reducing the temperature of the gas. Only after the coil in No. 6 began to

No date—June went to visit an aunt

flood, and the gas coming from that coil ceased to be superheated, was there too much liquid for the superheated gas from the remaining coils, plus the heat of the liquid on its way to the coils, to evaporate."

You again take up the question of the oil. "There was some oil in the accumulator," you comment to Frosty. "Twelve gallons of it. I took it out, because I thought that there would be more room for the liquid flooding back from the coils. Was that right?"

"Quite right," Frosty replies.

"But how did the oil get in the accumulator?" you ask. "I thought that oil trap up there between the machines and the condenser kept the oil from going around the circuit with the refrigerant."

"No oil trap made will remove every drop of oil," Frosty assures you. "Some of it will carry over into the rest of the system. And if this trap up here isn't blown down regularly, it will fill up and blow over into the condenser. From the condenser the oil can pass around the circuit with the refrigerant, and precipitate out wherever its inertia hurls it or the gas in which the particles of oil are suspended comes to rest. Besides, the oil may have been accumulating there for years. Terry never was a good hand to keep everything up to snuff."

"Another thing, Frosty," you are trying to think of all the things you intended to ask about, "What makes a compressor run so smoothly and quietly just before it starts to flooding. This one got so still this morning that I could hardly tell that it was running. I can't figure that out."

"That," says Frosty, "is caused by wet compression. When dry gas blows into a compressor cylinder and the suction valves close behind it, compression by the piston raises the temperature. This increase in temperature would raise the pressure of the gas if the poppet type discharge valves did not open somewhat earlier and let the gas escape to the condenser. During compression, some of the dry gas blows back around the rings and into the cylinder. When the return stroke starts, the gas, being very elastic, is compressed somewhat by the returning piston before the spring lets the poppet type suction valve open. On the other hand, if this gas being compressed contains particles of liquid, evaporation during compression prevents an excessive temperature rise. The liquid tends to collect momentarily on the walls of the cylinder, and seal the rings against gas blow-by. And on the return stroke of the piston the inertia of the liquid particles blowing into the cylinder compels the suction valves to start opening sooner and to open more gradually. These factors combine to produce quieter operation."

"While we think of it, better blow the oil out of the tank coils," Frosty says. "Also, you can try the blowdown valve on that other accumulator, the one there on the liquid receiver and the one on the condenser. Leave that main one till last, but be sure to get it. And be very careful with these high pressure blowdowns. They're tricky. I opened a blowdown once which gave me an oil bath. The bottom was full of sludge, a kind of mixture of oil and scale and litharge. Before the oil would blow, I had opened the valve pretty widely. Then all at once she blew. I was lucky to get the valve closed in time."

Frosty leaves. You find the oil blowdown line running up one side of the tank from the tank coils, and blow down 20 odd gal. of oil. You get only a slight amount of oil from the blowdowns of the condenser and liquid receiver, and none at all from the sharp freezer accumulator.

While you are busy the recirculating pump starts whistling. You inspect it, and find a motor bearing hot. Taking out a plug, you find the bearing dry. You fill the bearing well with compressor oil, having learned to distrust any other kind. While you are at it, you oil the bearings of the compressor motors, and the outboard bearings of the compressors as well, shutting down the machine to drain the old oil out and wash the bearings with gasoline before adding the clean oil. You remember the stuck grease cups on the agitator, and clean them also, refilling them with clean grease you get from the hardware store.

With the greasing and oiling completed, you decide to tackle that condenser tube-cleaning job. You climb to the top of the condenser and look down into the splash ring. There is a distributing ring into which the water coming down from the cooling tower pours. The ring rests on a strainer plate. A half-decayed pigeon lies on the plate. No wonder the water smells to high heaven.

From the top of the condenser to the ceiling you have just 3 ft. clearance in which you must work. You climb down and examine the cleaner. It is made with a standard ½ in. pipe thread onto which you screw a connection. Then you patiently cut and thread nine 2-ft. sections of pipe and get connections for them.

From lunch hour until nearly quitting time you work like a Trojan. You get set, ram the cleaner into a tube with one section of the pipe, screw on another section and ram the cleaner farther, all the way working it up and down. Your cramped position hinders you. The water running continuously into the condenser makes the pipe wet and slippery and hard to hold. You skin your knuckles twice and bump your head against the ceiling or a beam a half-dozen times. Altogether, you have cleaned 16 tubes when Allen arrives with the glad tidings that it is quitting time.

Quitting time, but not time to quit. You get down and start to clean the traps on the recirculating water line. The scale and algae that you have just cleaned off the tube walls did not go to the bottom of the condenser drain pan, as you thought it would. At least some of it has lodged in the strainers, together with quite a bit of the cottony substance to which is attached the prolific seed of the street's cottonwoods.

You are about to leave when you remember the thermoexpansion valve in No. 9 cooler. You dash into the storage and open up the valve. Just as Frosty said, the needle is missing. You are hopelessly reconciled to having to take a valve from the ice storage and install it in No. 9 when, Eureka! Allen comes in with the needle and spring. He has found both in a box of screws in the tool box. You won't be late for that date with June Frost after all.

But when you call at the Coldfax home that evening, you find that June has gone to visit an aunt who has suddenly taken ill.

(To be continued)

Plattsburgh Produces Power

BY A. C. KIRKWOOD
Associate Engineer
Burns & McDonnell Eng. Co.

ON THE shores of Lake Champlain, but a few miles from Canada, lies historic Plattsburgh, N. Y. Adjacent to the army post where early citizen training camps spread its name far and wide, Plattsburgh is a center for industries located in northeastern New York.

In 1935 the city officials ordered an engineering investigation of, and report on, the local electric utility rates and a determination of the probable success of a municipally owned power plant and distribution system. The city shortly decided by vote of the people to create a city owned utility—Diesel generating station and distribution system—to supply 60 per cent of the load. This competitive system plan was attacked in court and construction procedure was delayed for 4 yr. In November, 1939, the courts closed the issue in favor of the city and work was authorized. Financing was part by bonds and part by P. W. A. grant.

During construction the city entered into negotiations with the private utility company for purchase of their distribution system. After considerable effort the company and its receiver, the State Utility Commission, the P. W. A., and the city agreed upon a purchase price.

Meanwhile the power plant was constructed for only 60 per cent of the load. The private utility had purchased energy from the nearby hydroelectric plants. It was but natural that the prospective loss of revenue by the hydro plant operators should cause them to offer an attractive rate to the city. The city was interested in saving the cost of immediate enlargement of the plant. A contract was signed by which means the Diesel and hydro plants will interchange power, depending upon loads and available water supply, and the city will purchase their excess power requirements at a nominal cost.

After a triumphant court fight that lasted 4 yr., the City of Plattsburgh built a 3000-hp. Diesel power plant at a total cost of $256,464.19 or an equivalent of $122.13 per kw. of capacity. Tests indicate a fuel economy of less than 10,000 B.t.u. per kw-hr. at full load, 14 plus kw-hr. per gal.

Under these conditions and with this historical background, the power plant was placed in operation in April, 1941.

The plant was originally planned for three 600-kw. Diesel engine generator units, but with the 4-yr. delay the normal load growth indicated the desirability of increasing unit capacity to 700-kw. each. Specifications were prepared for these units based upon evaluation clauses which took into account economy of operation, types of design as affecting maintenance, and cost of major parts as maintenance items. Under these specifications were purchased three 1000 hp., 700-kw., 80 per cent p.f. Diesel engine-generator units. Rotating speed is desirably low—225 r.p.m. The engines are 4 cycle, 8 cylinder, mechanical injection units.

The three units are installed side-by-side in a reinforced concrete, steel, and brick building having space for but these three units. Decisions rendered by the courts indicated the desirability of insuring keeping construction costs below the limit of available funds. Consequently no chances were taken. Excess funds remaining after contract costs were known were diverted to distribution system rehabilitation.

Lake Water Not Used for Cooling

Although located on a peninsula jutting into Lake Champlain, the Plattsburgh plant does not cool with lake water. It so happens that variations in lake level coupled with extremely low temperatures render the lake useless as a cooling medium in midwinter. The shallow water often freezes to the lake bed for such distance offshore that any investment in intake and under lake pipe line would have been prohibitive. The extremely low temperatures would make cooling tower operation difficult due to icing. Evaporative coolers were installed, therefore, and were located in the power plant basement.

The firm capacity is 700 kw. This, coupled with due consideration to duty and performance, indicated that the jacket water cooling units could be purchased on the basis of two units, each of which would serve one engine for maximum load with maximum

Fig. 1. Municipal Diesel Plant at Plattsburgh, New York

wet bulb temperature. An additional unit was to be purchased later and space and connections were provided. Each of the two units has a fresh air duct connection to the outside at ground level with dampers. A damper opening into the basement provides means to take air out of the basement and engine room in summer. Moist, hot air is discharged through a duct open to the atmosphere at the switchhouse firewall level.

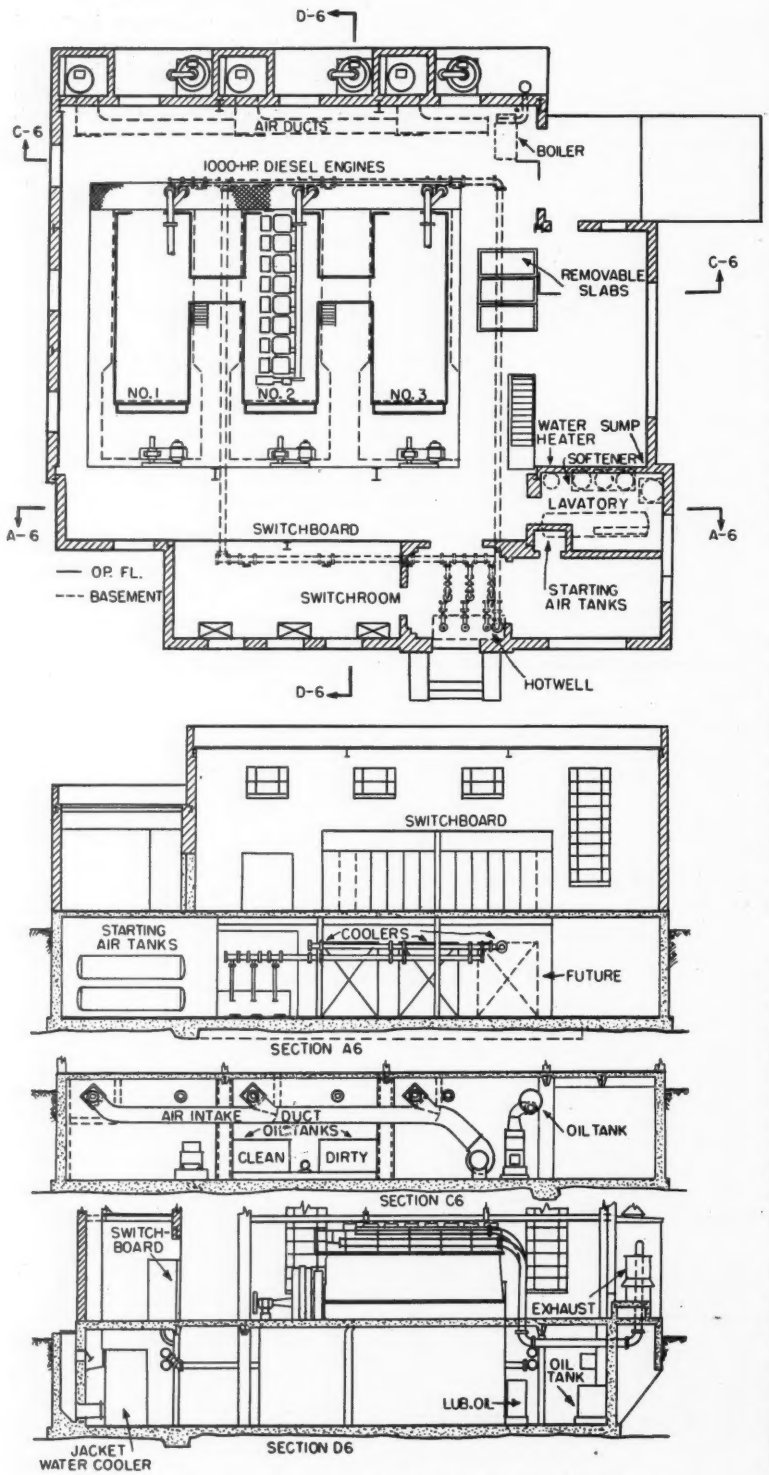


Fig. 2. Operating floor plan and vertical sections through plant

Jacket water must be supplied to the engines in suitable quantity and at desirable temperatures. In doing so the cooling coils must be protected from freezing. The solution to this problem was accomplished by two methods, the first of which required the installation of a hot jacket water bypass valve between the hot water inlet to the coolers and the cold water outlet. This automatic valve tempers the outlet water to the proper temperature. The second method is aimed at artificially raising the wet bulb temperature to prevent coil freezing and to assist the bypass valve and cooler by creating operating conditions which will necessitate passing a satisfactory amount of water through the cooling coils. These conditions are realized by installing a bypass between hot and cold air ducts with control by means of a manually operated damper. In other words, the plant operator creates the desired weather during the winter—and he has forced air ventilation in the summer.

Water Temperature Control

Jacket water from the engines flows by gravity to a hotwell located in part beneath the steps under the main entrance to the plant. The bottom of the hotwell is off the basement floor sufficiently to insure positive suction for the jacket water pumps—three 300 g.p.m., 80 ft. TDH units. Pump discharge and cooler discharge headers permit any pump or either cooler to serve any engine.

Raw water for the coolers is collected in a small sump in the base of each cooler and is sprayed over the coils. Make-up for the raw water system (and for the jacket water system when needed) is city water softened in a zeolite softener. Salt for regenerating the softener is stored under water in a concrete tank buried beneath the plant driveway. A manhole permits both easy access and filling.

Engine lubricating oil (crank case) is cleansed by an absorbent earth purifier using heating elements. This unit is arranged for use as either a batching unit or as a continuous bypass unit. For the former purpose a two compartment steel tank is provided, each compartment holding more than the quantity of oil contained in one engine.

Fuel oil is delivered by rail to two 12,000 gal. steel storage tanks located near the plant. An unloading pump is housed between the tanks. These above ground tanks are heated by the auxiliary heating boiler in the plant. Due to insurance restrictions the fuel is pumped to the day tanks located beneath the head end of each engine. A float switch mounted on each day tank starts either of the pumps and opens a solenoid valve supplying that tank. Fuel oil is purchased to specifications and consequently fuel oil purification equipment was omitted.

Exhaust mufflers are individually enclosed in brick chambers through which a central fan recirculates air for engine room and basement heating. Intake air cleaners of the Cycoil type are used for both cleaning and muffling. Although not designed for the latter purpose, they have proven very satisfactory on these 4 cycle engines.

Starting air at 250 p.s.i. is stored in horizontal tanks racked up on the basement wall. Supply is from one motor driven and one gasoline engine driven compressors.

Switch-gear is installed in a one-story addition to the engine room with the switchgear forming part of the engine room wall. Two exits are provided in the switchroom, one to the lobby and one to the engine room. Breakers are back-of-board type with bus, disconnecting switches, and instrument transformers located above and behind the breakers. Generating voltage is 2400 v. delta with all equipment arranged for future operation at 4160 v. wye. Station service transformers are suspended on the basement wall.

Fig. 3. Air filters and exhaust stacks are located at the rear of the plant

Plant Economy

Climaxing some 6 yr. of effort, the plant was tested and placed in operation in late April, 1941. Of interest is the fuel economy demonstrated during acceptance tests. Guarantees and tests were all inclusive in the sense that they were based on power delivered to the switchboard versus fuel input. Each engine was tested at three load points approximately ½, ¾, and 4/4 load; test durations were 1 hr., 1 hr., and 2 hr. respectively. Fuel was weighed in a batch tank which in turn supplied a fuel pump suction tank whose level was held constant by reference to a needle point gage.

Fuel used during the tests was the fuel which the city has purchased under an annual contract. The oil tested:

29.8 deg. Baumé, gravity
7.305 lb. per gal.
19,233 B.t.u. per lb.

The following table indicates the test results:

Unit No.	Average Load Kw-hr. per Hr.	Average Lb. Fuel per Hr.	Average Lb. Fuel per Kw-hr.	Average Kw-hr. per Gal.
1	340	194.7	.581	12.58
1	510	271.3	.532	13.72
1	690	355.0	.515	14.19
2	360	197.4	.548	13.32
2	540	268.3	.497	14.7
2	705	355.45	.504	14.5
3	360	204.1	.567	12.88
3	550	279.7	.509	14.35
3	670	338.2	.505	14.57

Construction costs exclusive of spur track, engineering, supervision, legal expense, and administrative costs incurred by the city amounted to $256,464.19 for the complete power plant. This is equivalent to $122.13 per kw. of capacity. The costs by individual contracts are:

Engine-generator units	$162,034.01
Structures	60,121.15
Heating and Ventilating	9,125.97
Switchgear and Wiring	16,723.30
Plumbing and Drainage	8,459.76
Total	$256,464.19
Estimated Cost	$274,421.00

Although in service but a short time, the plant promises to make an excellent record for economy of operation.

Design and supervision of construction was handled by the Burns & McDonnell Engineering Company.

LIST OF CONTRACTS AND MAJOR EQUIPMENT, PLATTSBURGH, N. Y.
Municipal Diesel Plant

Contract No. 1—Diesel Engine-Generators: Fulton Iron Works Co., St. Louis, Mo.

3—1000-hp., 700-kw., 225 r.p.m., 0.8 p.f., 60 cycle, 3-phase, 3 wire, 2400 v., with 125 v. excitation, Diesel engine generators; using General Electric Co. generators and exciters. Exciters V-belt driven. Engines are 4 cycle mechanical injection units with eight 17½ in. bore, 24½ in. stroke cylinders. Contract includes a "Hilco" lubricating oil reclaimer, with clean and dirty oil batching tanks, motor and engine driven 250 p.s.i. starting air compressors, air storage tanks, exhaust pyrometer, meters, and engine trim.

Contract No. 2—Structures: Bedford Construction Co., Utica, N. Y.

Contract is for reinforced concrete, steel, and brick building.

Contract No. 3—Heating and Ventilating: Hameline Co., Inc., Utica, N. Y.

Contract is for all building heating and jacket water cooling equipment, including two pipe gravity steam system with an oil fired boiler (Fitzgibbons), unit heaters in engine room, electric unit heaters in office and wash room, and forced air fan and duct passing air from basement through muffler chambers and into engine room. The jacket water coolers are two Buffalo Forge Co., No. 50D evaporative water coolers, 140 to 120 deg. F., 70 deg. F. wet bulb, and 3,000,000 B.t.u. per hr. each.

Contract No. 4—Electrical Work: Horacek-Hayden, Inc., Rochester, New York.

Contract includes power wiring and switchgear. The latter is of Westinghouse Electric and Mfg. Co. manufacture, and includes 3 generator panels, 3 city feeders, one station feeder, totalizing and regulator panel, and blank panels for future use.

Contract No. 5—Plumbing and Drainage: Hameline Co., Inc., Utica, N. Y.

Contract includes building plumbing and drainage, jacket water pumps, water softener, fuel pumps, and station piping.

One of the problems with which the refrigerating engineer of today is confronted is that of obtaining information on the properties of the newer refrigerants. In this article which is part of a paper the author presented before the American Society of Refrigerating Engineers, a method is described by means of which the unmeasured properties of refrigerants can be calculated with considerable accuracy. Besides a steam table only a working knowledge of critical conditions is needed

The Law Of Corresponding States As Applied In Refrigeration

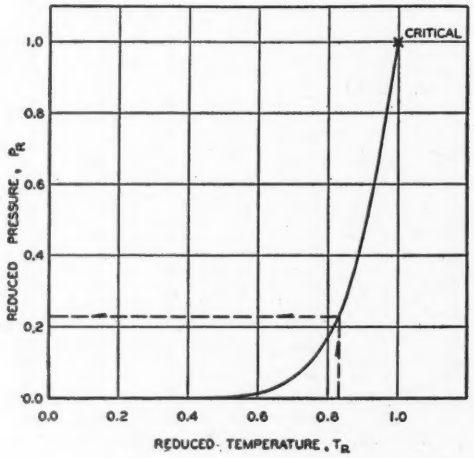
By J. S. DOOLITTLE
Asst. Professor of Mechanical Engineering
Pennsylvania State College

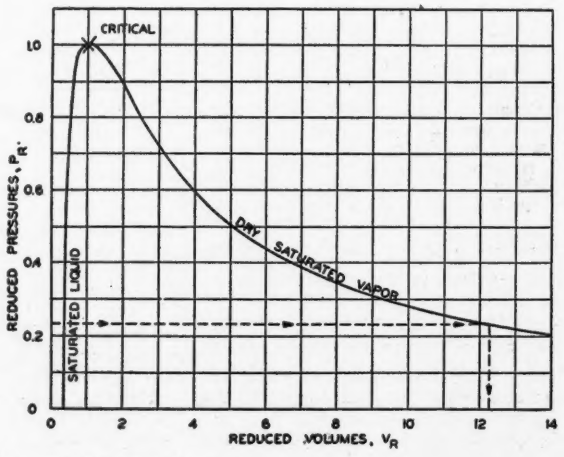
THE engineer of today deals with a large number of refrigerants. The thermodynamic properties of one of these, water, are well known and many tables are available covering a wide range. The properties of a second fluid, ammonia, are also very well known up to pressures of 300 lb. per sq. in. abs. Tables available for other refrigerants are rather limited in range. Furthermore, in dealing with new fluids little information of any sort may be at hand.

Difficulties due to lack of information may be partly overcome by the use of the law of corresponding states, which will permit some prediction of unmeasured properties.

This law is believed to have been originally stated by Van der Waals. His statement as given by Young follows briefly as: "If the absolute temperature of various substances be proportional to their absolute critical temperature, their vapor pressures will be proportional to their critical pressures and their volumes, both as liquid and saturated vapor, will be proportional to their critical volumes."

In dealing with this law it is convenient to "reduce" these properties to comparable conditions by expressing the properties as percentages of their critical properties. Thus two substances, each existing at 50 per cent of their respective absolute critical temperatures, are said to have the same reduced temperature of 0.5. Van der Waal's law is shown graphically in Figs. 1 and 2, reduced properties being used. If sufficient data are available for any substance obeying this law, figures may be plotted and used to determine the properties of all other such fluids for which we know the critical temperatures, pressures and volumes. Thus, suppose fluid A had a critical temperature of 1200 deg. F. abs., a critical pressure of 2000 lb. per sq. in. abs. and a critical volume of 0.05 cu. ft. per lb. Suppose its saturation pressure is desired at 1000 deg. F. abs., that is at a reduced temperature of 0.833. From Fig. 1 the reduced pressure is read as 0.23. The saturation





Figs. 1 and 2. Curves showing Van der Waals Law

Table 1. Critical data calculated from international critical tables

Substance	Crit. Temp., °F. abs.	Crit. Press., lb. per sq. in. abs.	Crit. Volume, cu. ft. per lb.
Ammonia	731.0	1657.0	.0686
Carbon dioxide	547.4	1069.9	.03454
Carbon monoxide	241.4	514.3	.05286
Ethane	549.6	708.3	.07624
Ethyl alcohol	929.2	927.5	.05813
Ethyl ether	840.1	522.0	.0611
Freon (F-12)	692.3	582.0	.0288
Helium	9.4	33.2	.2311
Hydrogen	59.8	247.5	.5164
Methyl alcohol	923.6	1156.2	.05885
Methyl chloride	749.2	969.2	.04388
Nitrogen	226.8	491.9	.05151
Octane	1024.4	361.5	.....
Oxygen	277.6	730.4	.0373
Sulfur dioxide	774.4	1142.0	.0308
Water†	1165.0	3206.2	.0503

† From "Thermodynamic properties of steam"—Keenan and Keyes.

pressure for substance A is, then, 0.23 x 2000 or 460 lb. per sq. in. abs.

The reduced volumes may be determined from Fig. 2 at the reduced pressure of 0.23. The reduced liquid volume is 0.4 and the reduced vapor volume is 12.3. Multiplying these figures by the critical volume of 0.05, the saturated liquid volume is 0.02 cu. ft. per lb. and the dry saturated vapor volume is 0.615 cu. ft. per lb.

The law has been applied mainly to the superheated vapors, little attention having been paid to the saturated region, which is of chief interest to the refrigeration engineer. The author has investigated the error in this law in the saturation region in the case of a variety of substances, differing greatly in their molecular weights, atoms per molecule, and critical properties. Steam was chosen the reference fluid. Saturated temperatures and volumes were calculated and compared with the generally available tabulated values.

Application of Law

The method used in determination of saturation temperatures may be illustrated by calculating the saturation temperature for ammonia at a pressure of 300 lb. per sq. in. abs. From Table 1, the critical pressure of ammonia is found as 1657 lb. sq. in. abs., and of steam as 3206.2 lb. sq. in. abs. The ratio of the critical pressure of steam to that of ammonia is 3206.2 : 1657 = 1.935. Then steam at a pressure of 1.935 × 300 = 580.5 lb. sq. in. abs. will be at the same percentage of its critical pressure as will ammonia at 300 lb. sq. in. abs. Thus 580.5 lb. sq. in. abs. is the *corresponding* steam pressure for an ammonia pressure of 300 lb. sq. in. abs. At this pressure, steam tables show a saturation temperature of 482.7 deg. F., 942.4 deg. F. abs. But the ratio of the critical temperature of ammonia to that of steam is 731 : 1165 = 0.6274. Then at 300 lb. per sq. in. abs., ammonia should have a saturation temperature of 0.6274 × 942.3 = 591.2 deg. F. abs. or 131.5 deg. F. This compares with the value in the Bureau of Standards tables of 123.21 deg. F. showing an error of 8.3 deg. F.

Corrections

Fig. 3 plots temperature corrections to be applied to calculated temperatures in order to obtain actual temperatures. In general, six to ten values of pressure, widely separated, were used for a particular substance. It was found that smooth curves could be drawn through the points with a maximum error of less than one degree. There is a sharp break in the carbon dioxide curve at the triple point; the temperature below the break is the saturation temperature in contact with the solid.

Other sets of curves on this figure refer to saturated vapor volumes and liquid volumes.

When the vapor volume correction factors (actual volume divided by calculated volume) were plotted, it was found that curves could be drawn through the points with a maximum error of 2 per cent. Although this error may appear to be large, it is quite probable that part of the error may be traceable to the actual volumes used, as our present tables for many substances are open to question. The liquid volume correction factor curves hit the calculated points with a maximum error of about one per cent.

Inspection of Fig. 3 shows that the calculated temperatures are appreciably in error at low pressures. It should be noted, however, that all curves are quite regular, that there are no crossing of the curves and that the curves are similar in shape. It may be supposed that a temperature correction could probably be made if one knew only one other point besides the critical by drawing a curve through this point, similar to the other curves. This was tried out and it proved to be the case, results checking within a degree.

Refinements to Van der Waals' Law

The same general procedure was used in case of vapor volumes. By use of the correction factor curves, vapor volumes were determined with a maximum error of 2 per cent. It is to be noted that the curves of liquid volume correction factors are quite irregular, with no general shape or direction. However, if a correction factor of 1.06 is assumed as applying to all conditions, then liquid volumes may be predicted with a maximum error of 6 per cent and an average error of 2 or 3 per cent.

(Continued on Page 83)

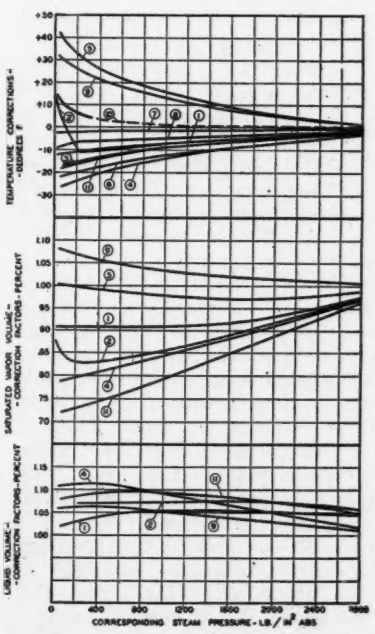

TEMPERATURE CORRECTIONS - DEGREES F
SATURATED VAPOR VOLUME - CORRECTION FACTORS - PERCENT
LIQUID VOLUME - CORRECTION FACTORS - PERCENT
CORRESPONDING STEAM PRESSURE - LB./IN.² ABS.

Fig. 3. Top—Temperature corrections; Center—Saturated vapor volume correction factors; Bottom—Liquid volume correction factors

(1) Ammonia; (2) Carbon dioxide; (3) Carbon monoxide; (4) Ethane; (5) Ethyl alcohol; (6) Freon; (7) Helium; (8) Hydrogen; (9) Methyl alcohol; (10) Octane; (11) Helium

Burning Low Fusion Coal

By careful selection of equipment and experimental operation, this small plant finally reached a high operating efficiency with a low-grade, cheap 2100 F. ash coal

By C. C. Harrington

IN YEADON, Pa., the Longacre Park Heating Co., a central heating concern supplies steam to some 1100 customers. As this steam is used entirely for heating, the sole concern of the management is to supply it as economically and reliably as possible. Furthermore, after the steam leaves the plant it never returns to the boilers. This 100 per cent make-up presents a nice problem in water treatment. That this problem is well in hand becomes apparent when it is learned that the boiler tubes of the two active boilers have not required cleaning for 4 yr. And as for economical firing, this plant burns a low fusion point, cheap coal that would put many plants out of operation in a few days.

But the enviable results attained at the Longacre plant were only realized after long months of trial and intelligent modification in boiler practice. The plant originally consisted of two 540-hp. Badenhausen, one 520-hp. Union, and two 220-hp. B. & W. boilers; they are all fired by underfeed stokers. Plant performance with these units was far from economical or satisfactory at high ratings. After an exhaustive study and investigation of other plants, Mr. Dolan, the plant superintendent, was convinced that pulverized fuel offered the best solution to his operating problem. With Mr. Hendrix, of the MackKenzie Enginering Co., he made some rather unusual changes in the boiler design of the two Badenhausen units and installed Strong-Scott pulverizers.

The first step was to lower the furnace floors 8 ft. and to redesign the three waterwalls so that the tubes would carry to this new depth. The front walls were designed to be air cooled, with provision for drawing this air from the walls to the pulverizers. To supplement this air, gas is drawn from the furnace and passed through a gas-air mixing valve to the pulverizers.

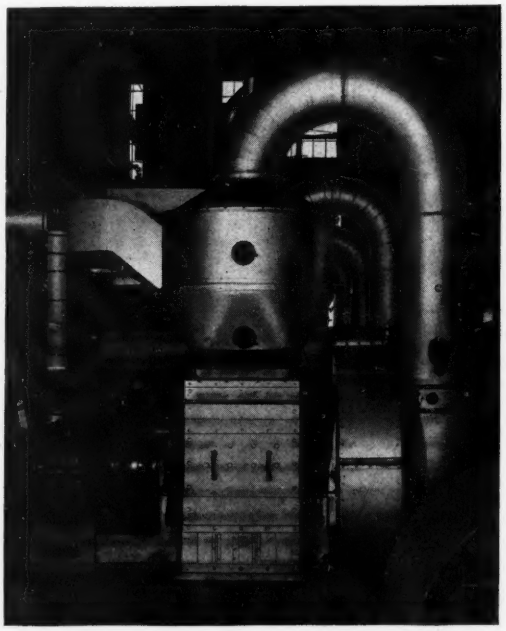
Narrow Furnaces

The problem was further aggravated by the narrow width of the furnaces, which measure only 8 ft. 9 in. from wall to wall. In order to get a proper distribution of flame in the narrow furnace, it was decided to install two separate pulverizers and burners for each boiler. Accordingly, one 3500 lb. of coal per hr and one 2500 lb. pulverizer were provided for each unit. This had the additional advantage of providing an efficient means of carrying a light boiler load during the late spring and early fall, when the demand for steam is small.

For driving the pulverizers it was decided to install an electric motor on one of the small pulverizers, and to use turbine drives on the other three. This gives a means of starting up after the plant has been shut down, and then getting a more efficient heat balance after the plant is in operation. Part of the steam from the three driving turbines and other steam auxiliaries is exhausted to the feedwater heater, and the balance of the steam is sold to the customers.

The performance of the redesigned boilers has been highly satisfactory. The units will carry a 300 per cent load continuously and efficiently, with a stack temperature of less than 600 deg. F. In fact the two boilers are used day after day to carry a load of 100,000 lb. of steam, which is equivalent to the normal demand on the plant much of the time. One of the other stoker-fired boilers is put on the line to help out with higher loads.

The most gratifying feature of the modified boilers, however, is the wide range of fuels that can be burned efficiently. Immediately after the boilers were put in service, Mr. Dolan began experimenting with various grades of coal. He finally settled on a grade of Pennsylvania coal with a fusion



Arrangement of pulverizers in the narrow firing aisle of the Longacre Heating Plant. One small and one large pulverizer is used with each boiler so as to give good low load performance

point of about 2100 deg. F. and a sulphur content in the neighborhood of 1 to 3 per cent. Although this type of fuel would be anathema to most power plant engineers, it is very satisfactory for the Longacre set-up. Its B.t.u. analysis runs around 14,000 and yet it costs considerably less than higher fusion point coals of the same B.t.u. content. The one thing that Mr. Dolan is careful to watch is the moisture content, which he insists must be kept around 1 per cent. Why, as he says, should he pay the freight on a lot of moisture.

This fuel, which would slag up the ordinary boiler in short order, causes no trouble at all in the Longacre boilers, even at loads of 400 per cent rating. The bottom type hoppers in the furnaces remove all the ash without any slag breaking or additional cleaning. The boilers are put on the line in the early fall and run continuously without shutdown until the warm spring weather. Even when the boilers are opened up for spring inspection, there are seldom any repairs to the brickwork necessary. Last season one of the boilers ran for a period of 235 days without being shutdown even for one minute. It was only taken off the line because of the end of the heating season.

Records

Mr. Dolan keeps a set of boiler performance records that would suit the most fastidious plant engineer. Flow meters are used extensively on all boilers as well as the 14 and 9 in. distribution lines. His efficiency checks show average monthly efficiencies up to 80 per cent, as compared with 60 per cent on the old stoker-fired units at high ratings. For his coal consumption he checks his own weigh larry figures against the railroad's weights. Even so he hesitates to believe that his boilers are operating consistently at 79 and 80 per cent.

Steam is produced at 120 lb. pressure and distributed at 40 lb. pressure. Feedwater is supplied at 210 deg. F. This feedwater, which once presented a serious problem, is now completely under control; so much so, that the tubes never require turbining, notwithstanding the continuous high rating on the boilers. All boilers are equipped for continuous blowdown. The heat from blowdown water is reclaimed very effectively by means of equipment formerly used for other purposes. Because of the unusual size of this equipment, the blowdown water is discharged at a temperature only slightly above the incoming cold water. The feedwater heater is of the open type with a capacity of 120,000 lb. per hr. The feedwater temperature is always well above 210 deg. F. and there is no evidence of corrosion.

The results now obtained fully justify the claim of Mr. Dolan that the best way to burn coal efficiently at high rating in these narrow boilers is in the pulverized form. With pulverized firing, each boiler is extremely flexible and will carry a swing of from 15,000 to 60,000 lb. per hr. without difficulty. In fact, every effort is made to operate at approximately 300 per cent, as experience has proven this to be the most efficient rating.

Rubber Belt Maintenance

Record of belt care, adjustment and service peculiarities are great help in avoiding shutdowns

WHEN AN IMPORTANT power transmission belt is put into service, every effort should be made to see that it has been properly chosen and correctly installed for the service which it is to perform, and with these preliminaries taken care of the life of the belt is then dependent upon the care given it by the operators. In many plants the care of all belting is placed in the hands of one man who is held responsible for all repairs, adjustments, cleaning, dressing and other maintenance work in connection with all belt drives in the plant. A good man in such a position can effect considerable saving in belt purchases.

In connection with rubber belting, the B. F. Goodrich Co. warns against trying to keep a record that is too elaborate as it becomes impracticable and unnecessarily expensive and indicates that it should be enough to have each drive numbered and tagged, and a record kept showing the following information:

- Number or name of drive.
- Department.
- Exact length belt should be cut.
- Width.
- Number of plies.
- Make of belt.
- Date applied.
- Date removed.
- Date when motor take-up is adjusted and number of inches motor is moved.
- Date when belt is replaced and number of inches taken out.
- Remarks.

Such data as speed of shafts, diameter and width of pulleys, horsepower transmitted, character of load and other special conditions of service should all be made available to the belt man for use at a moment's notice to assist him in avoiding or minimizing service interruptions.

Since rubber belts are permanently flexible and no dressing can penetrate into the structure of the belt without damaging it, belt dressing should never be applied except for a short period before the surface becomes sufficiently worn to transmit power smoothly. At this time and at any later period when a belt becomes glazed through slippage, the surface can be improved with the application of a vegetable oil, such as castor oil, tung oil or boiled linseed oil. Rosin dressings are particularly damaging to rubber belt surfaces.

Belting in Reserve

When it is necessary to remove ordinary dirt from rubber belts, use soap or trisodium phosphate, followed by rinsing with water. Accumulations of greasy dressing may necessitate the use of dry-cleaning fluids. One such fluid which avoids fire hazard consists of a mixture of 60 per cent carbon tetrachloride or Pyrene fluid and 40 per cent high test plain gasoline which does not contain lead tetraethyl. If used in large quantities, however, this mixture may not be best for the health on account of the fumes. Equal parts by volume of ethyl alcohol and carbon tetrachloride is another recommended cleaning mixture with qualities which make it safe in the presence of static electricity and temperatures up to 120 deg. F.

By systematic routine inspection, belt failures during service can usually be avoided. When the working condition of a belt becomes doubtful, it is better to replace the belt rather than run the risk of its breaking or running off the pulleys with the accompanying danger of damage to equipment, injury to workmen and an expensive emergency shutdown of machinery. When, however, quick replacements are necessary a convenient storage system is not only appreciated but a time and money saver.

Large users of belting find it convenient to maintain a rack with rolls of the commonly used sizes of belting from which the proper lengths can be quickly cut in case of need. These racks should be in dry, cool places and out of the sunlight as light is the most destructive factor in the deterioration of rubber belting kept in storage. Modern improved rubber belting contains anti-oxidants which preserve it for years without appreciable loss of service qualities.

Belts in operation should be relieved of static charges which can be satisfactorily accomplished by suspending a light grounded chain in such a way that it will touch the surface of the running belt. And for long life, belts should not be exposed to oil drippings as they cause swelling and gradual rotting.

Belt men have found many ways of salvaging parts of rubber belts, so a large belt may have considerable salvage value in the hands of a competent engineer. When belts of the foldless, or raw-edge, type become damaged along the edges, they can usually be cut to narrower widths, thus fitting them for other service. Worn plies can be stripped off and respliced on smaller drives. If the edges of recut belts are painted with a penetrating rubber cement, long service can be expected from carefully applied salvaged rubber belts.

AUTOMATIC Wood Waste Firing

How a small plant thrown on its own resources solved a wood waste fuel feed and boiler feed pump control problem in a very successful simple and ingenious manner. Not all difficult problems are confined to the large plant and a clever man can accomplish a great deal with little investment

By John U. Morris

EVERYONE IS, from time to time, confronted with a troublesome problem of long standing. Some of these cannot be solved simply, but with others a successful solution turns out to be astonishingly simple. This proved to be the case in the Wm. P. Curtiss & Son plant in Richland, N. Y., with the disposal of wood waste and shavings.

Like many furniture and wood working establishments the waste comprised between one-half and one-third of the total raw product. Coal was being purchased to supply heat for kiln drying and factory heat in the winter while in the summertime fuel in the form of wood and shavings was being carted away. Electric power was being purchased all the year around for some of the factory demands, while an old and inefficient slide valve engine was being coaxed into running some of the equipment.

Obviously the thing to do was to devise some method of burning the shavings and wood waste and generate power with the steam before it was used in the kilns. This was done. Furthermore, the plant was made entirely automatic, thus reducing labor for this department. The improvements were made in steps.

First a small underfeed stoker was placed under the lone 58-hp. boiler. This automatic installation eliminated considerable work for the fireman and was the start of other improvements. Next came a 50-kw. Ames uniflow engine and generator with voltage regulator, etc., then an economizer for the boiler, and last, but not least, was the automatic shavings burner and an automatic boiler water control using constant speed motors for the boiler feed pump but giving a variable pump speed.

The latter was a stroke of genius which completely eliminated the necessity for a full time operator. The plant is still watched and attended by one of the experienced factory men who can leave his work if it is necessary. For the last year, however, it has seldom been necessary, the plant runs itself in the true sense of the word, with no reserve equipment.

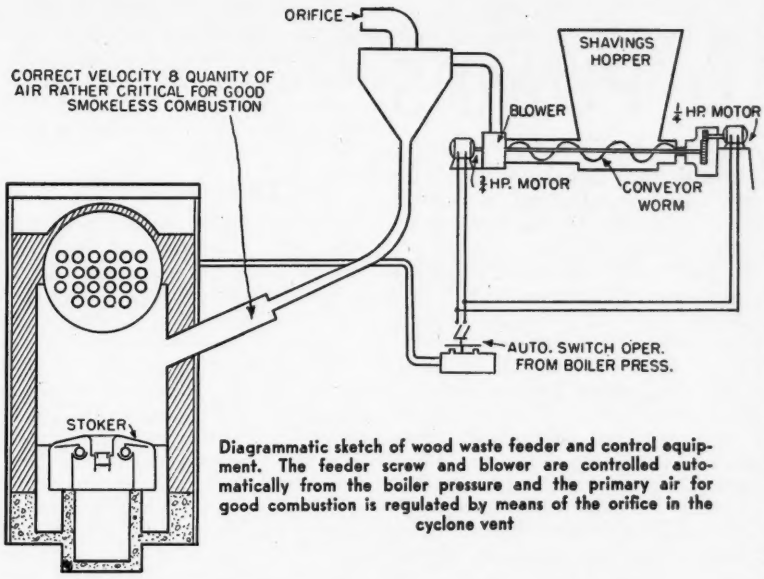
Briefly the plant consists of a boiler, engine and generator. It makes all the power for the factory and burns all the wood waste. The difference between the total fuel required and wood waste available is made up of coal. The two fuels are not, however, burned simultaneously. The maximum electric load to date has been 320 kw-hr. per day of 8.5 hr., but the average is around 250 kw-hr. a day or about 70,000 kw-hr. per yr.

In the winter time steam heating requirements exceed by quite a margin the amount available from the exhaust of the engine, therefore considerable live steam is used. In the summer the reverse condition holds true and the company is now thinking about a small condenser to further augment the efficiency of the uniflow engine during that period. The whole plant shows very clearly how intelligent thought and supervision can transform that particular department of a factory into a very nice paying division with no labor worries.

Wood Waste Feeder

All shavings are delivered to a special hopper built on the roof of the power plant, by the conventional duct and exhauster system. In the bottom of this hopper is a worm, driven by a small ¼-hp. motor, to feed the shavings into primary blower or fuel feeder as shown by the sketch. This in turn delivers air and shavings to a small cyclone separator located directly over the furnace. Both the motor driving the worm and the blower are connected to a Mercoid switch which is actuated by the steam pressure. When the pressure goes down, shavings are delivered to the cyclone separator and to the furnace.

It was soon discovered that proper burning of shavings de-



Diagrammatic sketch of wood waste feeder and control equipment. The feeder screw and blower are controlled automatically from the boiler pressure and the primary air for good combustion is regulated by means of the orifice in the cyclone vent

pended primarily on the correct amount of primary air fed with the shavings and the correct velocity of both air and shavings entering the furnace. This problem was solved by inserting an orifice in the vent of the separator and controlling the air released to the atmosphere. Control of this orifice is a good deal like controlling the temperature of oil in a mechanical heavy oil burner. It very definitely controls the amount of smoke and when the correct amount is determined by experiment, it can be left set for the most efficient combustion. Practically all of the shavings are burned in suspension.

Feed Pump Control

Automatic control of water fed the boiler with induction motors is even simpler than the shavings burner. There are two motors of standard speed belted to two different sized pulleys of a small gear driven plunger pump. The larger No. 1 pulley is "free wheeling"* and drives the pump along at a speed that handles a bit less than the average normal load of the boiler.

This No. 1 motor is started and stopped by a float controlled Mercoid switch independent of a second Mercoid switch that controls the No. 2 motor. Both of these switches are, however, actuated by the same float although they open and close at different water levels. This No. 2 is the larger motor (but with a smaller pulley) and cuts in when the boiler water level continues to drop. On heavy loads it cuts in often, on light loads seldom.

Operation is as follows: On very light loads the water level gradually rises and the switches operate to stop both motors. As the level drops, the No. 1 motor is cut in. If in the meantime the load increases to a point where the slow speed motor will not hold the level, it continues to drop and eventually cuts in the No. 2 motor.

During this period the No. 1 motor, due to the free wheeling clutch, operates at no load speed. The No. 2 motor driving the pump at over capacity raises the water level and is then cut out by the float switch. This leaves the No. 1 to carry on until the water level again drops to cut in No. 2 again or raises to cut out No. 1. When motor No. 2 (high speed) is cut out it is carried along partial speed corresponding to the lower shaft speed of the No. 1 motor.

In addition to the variable speed pump controlled by the two switches actuated by a single float, there is another similar pump actuated by a separate motor and controlled by a separate float switch. This pump in normal operation never comes into use, but is simply intended for emergency operation in case, for any reason, the main (variable speed) pump fails to work.

As a further safeguard, the float switch controlling this pump also serves to cut off the stoker (either coal or shavings) until such time as the water level is again restored. This emergency pump control is set to trip in when the water-level in the boiler drops about ¾ in. below the point where the high speed drive on the variable speed pump trips in.

Feedwater goes to the boiler through a feedwater heater and then through an economizer located in the uptakes of the boiler. Due to this economizer and inherent efficiency of the uniflow engine this plant is particularly economical and is said to show unit cost results far ahead of industrial plants many times its size. Fixed costs are at an absolute minimum for everything runs at near capacity when the factory runs, and there is no spare equipment to keep in shape.

*Editor's Note: An inquiry regarding additional details of the "free wheeling" clutch brought the following from Mr. Curtiss via the author: "The free wheeling device was made from the starter drive from an old model Studebaker automobile, and was purchased at a junk yard for $1.50. The float controls are Mercoid—also remodeled by the addition of extra switches (mercury) and grease fittings to lubricate the packing. Before we installed the grease fittings the glands had to be repacked about every 2 mo. to prevent sticking; now repacking once a year is plenty. The switches controlling both motors are actuated by the same float. By this method the cut-in and cut-off points of both motors have a constant relation to each other and are therefore not affected by variation in float packing gland friction as would be the case if they were actuated by separate floats."

Corresponding States Applied to Refrigeration

(Continued from p. 79)

Van der Waals' law yields rough approximations of pressure, temperature or specific volumes of a saturated fluid. However, if the temperature and specific volume of the fluid is known at any other pressure than the critical, then by use of the correction curves given in Fig. 3, these properties of the saturated fluid may be estimated over the entire range close enough for most engineering work. Van der Waals' law as refined by the author thus becomes an engineering tool.

In passing, it should be noted that the calculated volumes of those substances with very low boiling temperatures, such as helium and hydrogen, are in much greater error than those substances shown on the curve sheets. This is largely because of error in the predicted temperature. Thus the calculated temperature for hydrogen at 26 deg. F. abs. is in error by 9 deg. F., which is a percentage error of 35 per cent. It is the percentage error that affects the volume. Outside of this one instance, no relation was found between the magnitude of the error and critical conditions, molecular weights, or atoms per molecule.

HIGH HEAD PUMPS

SOME YEARS ago at the Santa Rita (N. Mex.) Mines, the Nevada Consolidated Copper Corp. drilled a 2115 ft. well for general water supply. It ranges from 17 down to 12 in. in diam. and the pumping level at times approximates 1000 ft. The well was pumped by air lift which was not satisfactory, first because of the high power cost, second because the aeration precipitated lime which scaled the walls of the discharge column and air columns.

Some time ago the air lift was replaced with a 10 in. diam. 22 stg. porcelain lined bowl, Byron Jackson Submersible pump driven by a 100-hp. motor. This reduced the power requirements about 75 per cent and practically eliminated the lime deposit for there is no aeration of the water.

The pump is set 1074 ft. in the wall and is frequently started and stopped. The water in the column was originally allowed to flow back freely when the pump was stopped as a result of experience with settings up to 730 ft. After 6 wk. however, water hammer cracked the lower motor bracket casting.

Two hollow brass check valves were then installed in the column, one at the pump, the other 500 ft. above. Ports allowed the water to drain down slowly. The valves absorbed the water hammer, but collapsed after 8 mo. service. They were then replaced by a single stainless steel check valve of the disc type as used with high pressure oil drilling equipment when abrasive material is pumped. The valve has a vertical lift of 3/8 in. with a small hole for draining the column. It is located immedately above the pump and has proven entirely satisfactory.

Kit Carson—Miner

These mines were first operated by prisoners under the Spanish in 1790. Underground mining was used and only the native copper, still found at the lower levels, was used. One of three round adobe forts built at that time is still standing. In 1845 the mines were operated by Kit Carson and Putty Brothers. Modern operations started in 1880 and it has been continued under different names to the present, now being a subdivision of the Kennecott Copper Corp. It is now one of the largest open pits in the world. Some 108 million cu. yd. have been removed and the depth from the highest rim point is about 700 cu. ft.

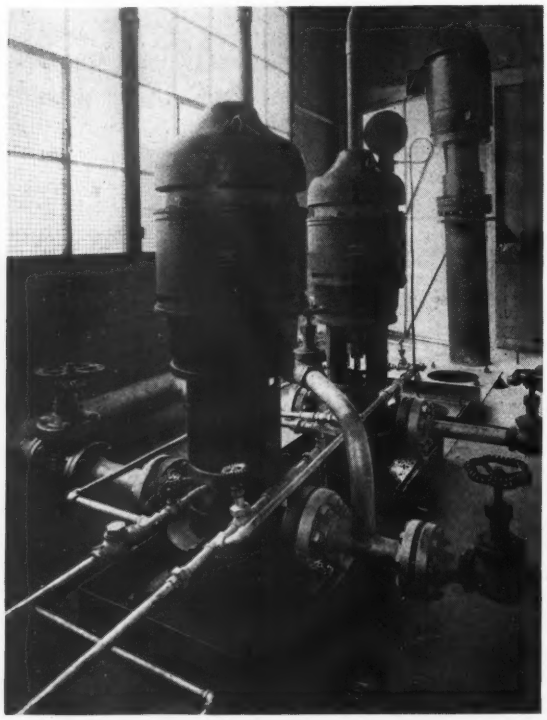


Fig. 1. Three of several Hydropress (see p. 76, March, 1941) pumps in the Harvill Aircraft Die Casting Corp. in Los Angeles, replaced individual press pumps. Four pumps are planned for this installation, two 50 and two 75 g.p.m. units, all for 500 lb. pressure. By operating different combinations, capacities of 50, 75, 100, 125, 150, 175, 200 and 250 g.p.m. can be obtained so as to give minimum power consumption at all loads. When 1000 lb. pressure is required two similar pumps can be operated in series to give 50, 75 or 125 g.p.m. Note the simplicity of the piping, with the suction line at the left and the "series" connection crossing over between the two pumps in the foreground. The pump in the background, complete with motor is just being set into position

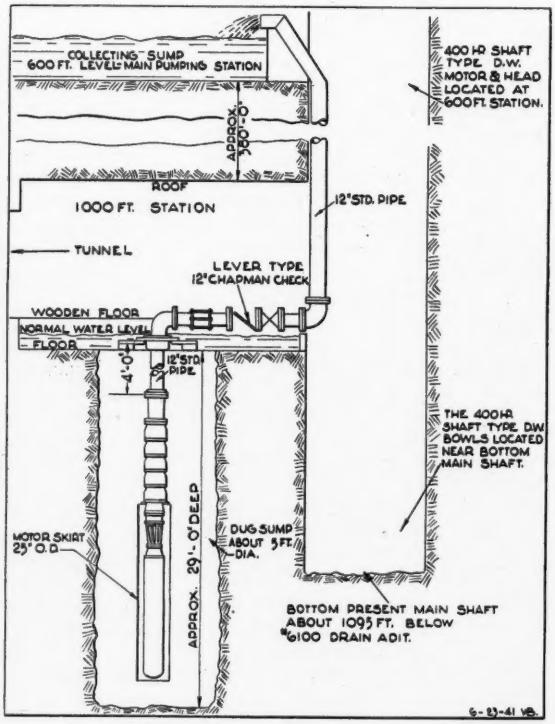

COLLECTING SUMP
600 FT. LEVEL MAIN PUMPING STATION
400 HP SHAFT TYPE D.W. MOTOR & HEAD LOCATED AT 600 FT. STATION.
APPROX. 100'-0"
ROOF
1000 FT. STATION
12" STD. PIPE
TUNNEL
LEVER TYPE 12" CHAPMAN CHECK
WOODEN FLOOR
NORMAL WATER LEVEL
FLOOR
12" STD. PIPE
THE 400 HP SHAFT TYPE DW BOWLS LOCATED NEAR BOTTOM MAIN SHAFT.
MOTOR SKIRT 25" O.D.
APPROX. 29'-0" DEEP
DUG SUMP ABOUT 5 FT. DIA.
BOTTOM PRESENT MAIN SHAFT ABOUT 1095 FT. BELOW 600 DRAIN ADIT.
6-23-41 VB.

Fig. 2. Schematic diagram showing how the Gray Rock Mining Co., Jarbidge, Nev., uses a Submersible pump (see p. 345, May 1938) to solve a troublesome problem. A deepwell turbine in the shaft at the 1000 ft. level delivered 2600 g.p.m. to booster stations on the 600 ft. level. Opening the tunnel developed an unexpected flow of water which made it necessary to close the heavy steel door and temporarily abandon operations. The real difficulty lay in the power supply, for, in case of failure the standby Diesels can handle the pumps only down to the 600 ft. level. Without pumping water rises in the shaft approximately 4 ft. per min. without considering the extra water impounded in the new tunnel. The new 400-hp. pump supplied with power through a waterproof cable, and dewatering can be resumed as soon as power is restored

The PRACTICAL ENGINEER and ELECTRICIAN

ANDREW W. KRAMER, EDITOR

STILL GROWING

On page 91 we present a recent photograph of George Hawkins' "Fused Man" featured in various issues of Power Plant Engineering during the past year. For the benefit of those who may not have seen these issues, this "Fused Man" is a collection of old and interesting electrical fuses arranged in the form of a huge robot looking man. Since we first published his picture in November of last year he has grown a lot and is still growing. As a result of the publicity we gave him and which he received in newspapers and over radio broadcasts, people from all over the country are still sending in fuses, indeed, he will soon have to be reconstructed and given a better "foundation." One of the most recent additions to his "fuseatomy" is a plug fuse sent in by Carl Anderson, keeper of the Sandy Hook Bay Lighthouse, built in 1856. Mr. Hawkins has asked us to announce in this column that he will be glad to lend him out for exhibition purposes. He has been exhibited in various places around New York City and is a great attraction for both young and old. If anybody is interested in exhibiting him we will be glad to forward your communication to Mr. Hawkins.

A. W. K.

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Shop Talk 100

A Section of Power Plant Engineering Devoted to PLANT OPERATION AND MAINTENANCE

Technical Publishing Company
53 West Jackson Blvd., Chicago, Ill.

Engineers for some peculiar reason always remain engineers, even when they are not engaged in engineering. Here is a short discussion on their behavior as mountaineers. Their belief in the virtues of calculus is sometimes pathetic, but being sincere one can like them despite their funny ways

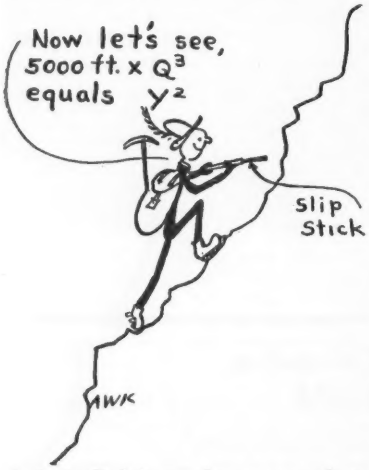
Engineers Are Funny That Way

BY ANDREW KRAMER

ENGINEERS as a class are rather strange animals and their ways often curious. They possess a profound understanding of the laws of nature and they know the properties of matter; their skill in the use of mathematics is baffling to the layman; they possess remarkable analytical powers; yet, frequently, they do silly things. Their inherent tendency to be logical often causes them to "lean over backwards" and as a result they find themselves in amusing if not embarrassing predicaments.

Woman's Intuition

A woman's intuition can often accomplish in a matter of minutes something which may take an engineer with a deep-seated belief in the virtues of calculus 3 days. In an instance that came to the author's attention recently, a girl secretary in the engineering department of one of our large electrical manufacturing plants spent just 3 min. in giving an accurate answer to a simple puzzle problem that had already occupied the attention of an engineer in the same department 2 days and he still did not have the correct answer. He was trying to solve it by the use of calculus which was unfortunate because it required only simple arithmetic and some common sense. The girl knew nothing of calculus, but she had common sense and used it. The engineer's belief in the necessity of using calculus got the better of his common sense.



A day's climb is equal to so many foot pounds of work

The reasoning instinct in engineers and men of science in general is probably the reason they make poor politicians. A politician can sidestep, without batting an eye, a situation which to an engineer may seem of tremendous logical importance, yet in the end, the public's interest may be served as well by the politician's intuition as it would have been by the engineer's logic. Sociology still remains more of an art than it is a science.

They Like It

These thoughts on engineers and scientists were engendered by one of the author's vacations in the western mountains. Mountaineers to non-mountaineers are, of course, a bit daffy—plain nuts in the parlance of the times—and this being so, no attempt will be made here to explain why people climb mountains except to state that they enjoy it. They enjoy it even more, perhaps, than some other types of individuals profess to enjoy knocking a small white ball around an open field. There is really no accounting for tastes; some men take to women, others take to drink and still others take to mountains.

Among mountaineers are to be found men and women of all ages and of all interests and professions, including, as one would expect, engineers and scientists. These engineers enjoy climbing quite as much as members of other professions—doctors, lawyers, professors, artists, etc. Strangely enough, there are few business men among mountaineers.

Even sandwiches represent so many B.t.u.'s

The engineers, even in the mountains, still remain engineers. They are fully as conscious of the beauties of the mountains as anybody else, perhaps even more so, but they always remain loyal to their first love—science. They are forever translating

The laws of probability can always be counted on to calculate one's chances

their climbing and camping activities into scientific language; they never seem to want to forget their formulas, their mathematics, and their theories.

Climbing with a Slip Stick

A day's climb will be equivalent to so many foot pounds of work. A sandwich represents a certain number of B.t.u.'s heat value. A steep shale slope brings forth discussions on angles of repose, while a red sunset is liable to end in a lecture on the selective absorption of frequencies by the atmosphere.

The lawyer doesn't worry about these things; a climb to him is an enjoyable day's outing and he does not attempt to associate his activity with legal matters, but his engineer companion calculates his progress in terms of foot pounds and is likely at any moment to announce that they are working at the rate of a fifth of a horsepower, or that the breaking strain of the rope has been weakened by 43 per cent because of the rock that fell on it a while back.

Everything is subject to calculation. When negotiating a traverse in the path of falling rocks, the engineer will employ the theory of probability to inform you what your chances are of reaching the other side of the traverse alive. Casting his eye on a steep snow slope above, he announces that it is just about at the critical angle and that it is liable to avalanche at any moment.

Not that his thoughts are always on the morbid side. Even the most commonplace things are subject to scientific analysis. One noted scientist from the Bureau of Standards at Washington developed a formula to determine one's progress in walking over mountainous terrain—so many miles horizontally, so many feet up, so much of the distance over snow and Ergo! you've got your total walking time. It doesn't always work, but it makes a fine subject for discussion on the trail.

What Goes Up Must Come Down

The question of where the energy goes that one acquires in going up a mountain when one goes down again is always a good subject for the scientifically minded mountaineer. Everybody knows that when a body is lifted to a certain height it acquires potential energy. In electric railroad practice this energy is recovered by regenerative braking on the downward grade. What about the mountaineer? Where does his potential energy go when he descends? It would be fine if we could develop a regenerative technique in mountain climbing. The skiier is more successful than the mountaineer in this respect; he recovers the energy that he acquires in climbing uphill, but the mountaineer often works as hard going down as he did going up. Maybe that versatile genius, Pulverizer Pete, can shed some light on this question.

One Good Mountaineer = One Electric Fan

Only a hard working mountaineer can really appreciate the power of an engine or other prime mover. Climbing mountains is hard work, about the hardest work that human beings can do. On a major climb, involving a peak say 12,000 ft. high, one will start from a camp pitched at 5000 ft. elevation. This represents a difference in altitude of 7000 ft. and under favorable conditions such a climb can be made in 8 hr. In the case of a person weighing 150 lb. carrying a pack of 20 lb. and including 10 lb. of clothing, over 8 lb. of which is in heavy nailed shoes, the total weight to be carried up is 180 lb. This carried up 7000 ft. represents 1,267,000 ft. lb. of work and if it is done in 8 hr. the climber works at the rate of 2640 ft. lb. per min. This sounds impressive, yet when one considers that the unit of work, the horsepower, is equal to 33,000 ft. lb. per min., the 2640 lb. loses some of its impressiveness. It represents a rate of work of less than 1/10 hp. In other words, a good mountaineer in perfect physical condition can do continuously only the work of a good size electric fan motor.

A good mountaineer is only the equal of a large electric fan

So, even after the engineer-mountaineer gets through with his calculations, the results are somewhat disconcerting. Such cogitations are perfectly harmless, however, and do nobody any harm.

There is a species of scientist, however, whose theories at times are annoying—the one having dizzy ideas about food. The writer recalls to mind one expedition which included a chemist and a physicist. The chemist would drink no tea because it contained tannic acid while the physicist would drink no coffee because it contained cafeine. Eggs for breakfast were no good, said the chemist, because they contained sulphur and that was bad. Neither of them would use white bread because that had the vitamins removed.

In fairness to the scientists it must be admitted that many others besides scientists are food conscious, especially these vitamin filled days. On this last trip the writer traveled for a while with a gentleman of the legal fraternity who carried three different kinds of vitamin pills, took glucose and salt tablets every 2 hr., consumed great quantities of gelatin and who never got tired of talking about food theories.

They Never Grew Up

The engineers, however, are the boys that really shine when it comes to theories, and quite often they put them into practice. There was the engineer, for example, who arrived in camp with a strange new type of sleeping bag he had invented. It consisted merely of two layers of light, water-proof fabric. The idea was to fill the space between the two layers with spruce boughs and the resulting dead air space would form an insulating layer which would keep the sleeper warm even in the coldest weather. Again the theory underlying this device was probably better than its performance, but it gave the inventor a great deal of pleasure to explain its action to all who would listen.

The point of all this is to show that engineering must be an interesting profession. People in most walks of life are glad to forget their work while on a vacation, but engineers and scientists don't seem to want to do this. They enjoy their holidays quite as much as the others, but they find additional enjoyment in applying their knowledge of natural laws to their vacation activities. Their faith in natural laws often cause them to do silly things, but they seem to enjoy doing them. They are really boys that never grew up. They are funny that way.

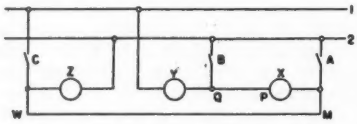
FOR THE PLANT ELECTRICIAN

HINTS ON ELECTRICAL WIRING INSTALLATIONS

By Eugene George Key and Clyde Nelson Shupert

In spite of the fact that most electrical wiremen almost automatically do their work properly, some mistakes are still made. That some rather dangerous conditions are wired into an installation is evidence by the diagram accompanying Question 101 in the March, 1941, issue of The Practical Engineer and Electrician.

In that picture was shown a series generator with a circuit breaker on one side of the generator armature and a knife switch on the other side, leaving the series field connected solidly to a live bus. In case of trouble in the series field in an installation of that kind, the bus would have to be killed and much equipment shut down until the field could be disconnected from the bus by hand. Even if no trouble occurs, the condition is a hazard, as any work that is done on the generator must be done on it while part of it is alive.



An example of peculiar house wiring

Whether wiring generators, motors, or lights or any other equipment, the electrician should always connect that equipment so that it can be completely removed from any live bus or circuit. Just how the disconnection is to be made is not always important, as a fuse will sometimes be as good as a circuit breaker or a switch if the fuse is in not more than one leg of the circuit. If one side of the electrical circuit is grounded, the fuse can be placed in that side, but all switching equipment must be connected so that it opens the "hot" (ungrounded) side of the circuit. It may be connected so as to open both sides, but if it is connected to open only one, then that side must be the "hot" wire. Fuses have been known to carry currents in excess of their rating and are not to be considered adequate protection without the switching equipment for either manually or automatically opening the circuit.

Suppose the switching equipment is put on the grounded side. Even when the switch is open, the circuit may then be considered alive, as a ground on any part of it will cause electricity to flow. If, however, the switch is in the "hot" side, a ground occurring in the circuit will merely put a second ground on the part of the circuit that is already grounded and no danger is experienced until the switch is turned on. At that time, the fault immediately reveals itself and the operator can open the circuit before the results are serious.

Another common fault in electrical wiring is the failure of the wireman to properly identify the wires before pulling them through conduit. Some of the most ridiculous results imaginable are found in installations as a result. One of the most glaring examples of this kind was a house-wiring installation, a schematic diagram of which is shown on this page.

The original intention of the wireman was for switch A to operate kitchen light X, switch B to operate dining room light Y, and switch C to operate porch light Z. Wire WM was to connect wall outlets.

Actually, switch A—as the diagram shows—connected lights X and Y in series with switch B turned off. If switch A was left on, switch B would light Y to full brilliancy and light X would go out. With A and B turned off, switch C would operate Z and connect lights X and Y in series so that both would light at very low brilliancy, while light Z would be at full brilliancy.

With B on or off and A on, if C were turned on, a fuse would blow because only switches A and C would be connected between line wires 1 and 2. Nearly all of the wall outlets in the house were dead at all times.

The electrician called in on the job had to disconnect every splice and connection between line wires 1 and 2 and identify nearly every wire. When the identifications were made, the proper wires were spliced together and the installation operated as it was originally intended.

Wires are usually partly identified if the proper procedure is followed in using white for the neutral wire and black or red for the "hot" wire. If only black wire is used, identification is not so simple. The best way is to cut notches about an inch apart at each end of every wire. One wire could have one notch at each end; another, two notches; and so forth. If BX is used instead of conduit, two-wire BX will contain one white and one black wire. Three-wire BX will contain an additional red wire, so that identification is made without notching. The use of tags is not to be permitted for conduit wiring, as the tags will be pulled off in the conduit.

In the installation described, only black wire was used. Had the proper colors been used as indicated in the above paragraph, at least part of the difficulty would have been overcome. If line wire 1 in the diagram was the grounded side, it would be white. Line 2, of course, being the "hot" side, would have been black, and all switches would have connected to this line. Wire PQ, being the return from lamp X, being a white wire, would have connected to line 1 instead of to the "hot" side of light Y. Wire WM would then have to be disconnected at M and reconnected as a feed for the wall outlets.

In using BX, the white wire is sometimes used for the hot side of the system in running from the switch to the light. When that is done, the wireman must be a little careful but should not experience any particular difficulty in making the proper connections.

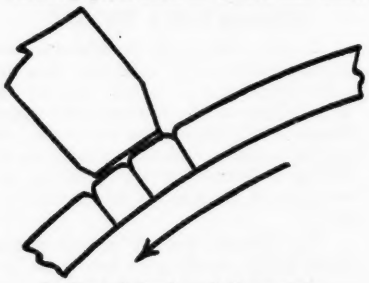
Notes on the Maintenance of Electrical Equipment

By Edward A. Hansen

The following notes, based on experience in our own plant, may be of value to others operating electric generating equipment. These methods have been tried and tested and they have prevented much of my hair from becoming grey during the past 6 yr.

Our main exciter is turbine driven at 3600 r.p.m., and really is supposed to be used only as a starting exciter, but we have to use it continuously. With heavy load, high speed, high brush friction, it provides everything to give an operator grey hair just trying to keep it in shape.

The commutator used to get so hot as to melt the connection between bars and winding, thus shutting us down or reducing plant load to where our other exciter could handle load. After trying different types of solder we finally found a brand that is of much higher melting point, and this, together with the use of a small fan blowing cold air on the commutator, has relieved us from further trouble.



Section of Brush and Commutator

Another thing that gave us much trouble was poor brush contact with the commutator. Regardless of theory, I have found that on high speed exciters, brush contact area can be much less than it is supposed to be and still give perfect commutation, long brush life and keep the commutator in fine shape. In the accompanying illustration are shown two commutator bars, undercut mica and cut heels and toes of the brush on a high speed unit. The two bars are 5/8 in. wide, including the mica. The brush itself is 5/8 in. thick, but at the point of contact I have trimmed the edges so as to cover only one and one-half bars.

It is essential, of course, to cut all the brushes exactly the same way and to make certain that they are equally spaced and in line on their respective bars.

Brush materials are important. Be certain to get a grade of material most suited for the work. By testing a number of grades we are using brush materials not even recommended for these places, but their use has resulted in longer brush wear, freedom from sparking, etc., and, after all, that is what the "boss" wants.

About voltage regulators of the vibrator type: I have been in plants where the voltage regulator was always "acting up" and have found that the old laws laid down by an old chief when I was a young un are mighty good to follow. After the regulator is properly installed there are very few things that need changing or "fixing". The relay contacts should be given a proper clearance so that a wiping or rubbing contact is made, or about a full $\frac{1}{32}$-in. gap when holding lower contact down—providing the upper or stationary contact spring is set so as to give, and then spring back at time of contact and release. This is important, as this movement produces a wiping action that aids contact faces. Each 24 hr. the current should be reversed in relay contacts as this helps to keep contact faces even and free from pitting. A very fine Crocus cloth is used to polish relay contacts once a day when regulator is "off the line." The main contact points need only to be kept in adjustment so that a slight wiping contact is made.

Oil the pivot bearings about once a month with a high-grade light oil. Bearings on relay contact arms should be snug, with just a slight sideways movement which helps to keep contact faces clear. These simple rules will help in keeping the plant free from trouble.

Keeping Down Spouts Thawed Electrically

THE JOB of keeping rain gutters and spouts free of ice during the winter months is easily accomplished by installing the new lead covered soil heating cable along the more severely affected sections of the drain system.

This cable is obtainable everywhere with resistance values suitable for coupling to 115 v. mains and those instances where 220 v. service is available two sections may be coupled in series. To conserve power during periods of mild weather a thermostatically operated switch is employed to "cut" the cable in or out as the weather requires, however, where an attendant is constantly on duty as is the case at our hydroplant manual control suffices.

This probably is also the opportune time to suggest that when gable roofed buildings are constructed one can profit from our experience where we blundered in placing the gutter along the roof's lower edge where tons of ice formed to confound us.

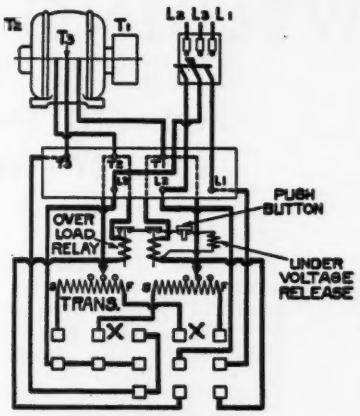
The condition was rectified, at considerable expense, by shifting the gutter up the roof to a position directly over the wall where the water was intercepted ere it cooled. Also wherever it was practical, the down spouts were shifted to indoor positions to provide straight runs and to avoid freezing.

The cost of maintaining the cable has been negligible during the 5 yr. it has been in service while power costs average in a reason's run to approximately $5.50 at 1¼c per kw-hr.

Emergency Repairs to a Potential Starter

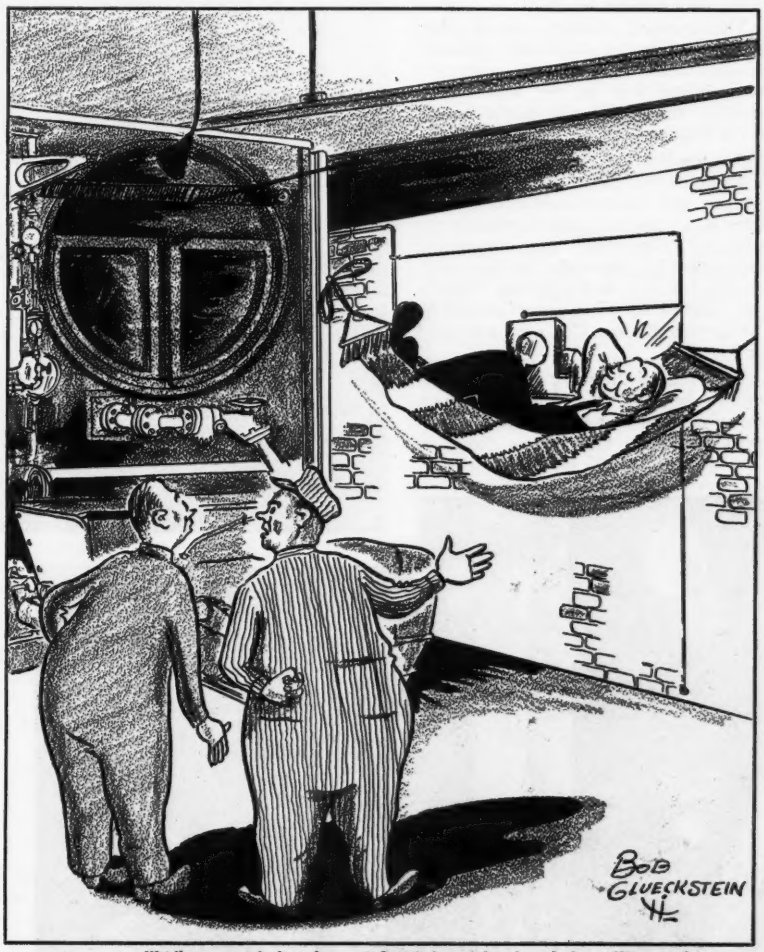
By P. C. Ziemke

A BLUNDER ON the part of an employe when installing a motor controller caused the transformers to burn when 440 v. potential was applied in place of the proper 220 v. Having no spare starter and not wishing to throw the 6 hp. 440 v. motor across the line because of the heavy starting torque required on the punch press we experimented to determine if it were possible to utilize the starter in its damaged state. The oil besmirched diagram pasted in the starter's cover was of little use since its lines were too vague to be followed. However, once the oil pan was removed, the circuit could be traced and plans laid for some



THREE PHASE
Diagram of Starter

changes. These were accomplished by cutting off the taps from the contacts at the points marked X thereby utilizing the transformers as choke coils on the starting position. Which, since the voltage is 440, serves nicely to reduce the initial rush of current and thereby protects the motor until the required momentum of the punch press is obtained. Of course the T 1 taps were moved to the A 3 as the instructions recommend.



"What can I do about it? He's on his lunch hour!"

WELDING PRACTICE

SABOTAGED ENGINES REPAIRED BY WELDING

THE USEFULNESS of electric arc welding in relation to the National Defense Program was strikingly illustrated in the repair of the sabotaged engine of the S.S. Villaperosa, one of the interned Italian cargo vessels in New York.

These repairs were completed in less than 2 mo. by arc welding, whereas to have reconditioned the ship by the installation of replacement parts would have taken at least a year.

Damage to the engine consisting of breakage of the bedplate into literally thousands of pieces resulted when the huge crank arms, turned over by compressed air, jammed against heavy pieces of steel which were placed by saboteurs on the bedplate underneath the ponderous arms. The pieces of bedplate were said to resemble little more than the parts of a huge metal jig-saw puzzle when the repair crew started to work.

The principal damage, caused when the 19-in. diameter crankshaft jammed the huge arms onto the steel resting on the bedplate, was at the approximate center of the engine and in the middle of the frame.

Arc welded repair consisted of fusing the many broken pieces of cast iron back together and joining re-inforcing steel plates to steel dowel pins inserted in the bedplate. "Ferroweld" and "Stainweld A5" arc welding electrodes, together with 200 amp. electric motor driven "Shield-Arc" welding machines manufactured by The Lincoln Electric Co., were employed for the work.

First step of the work was the veeing out, or beveling, to 45 deg. of each broken piece of cast iron. This was followed by fitting the various pieces in place and tack welding (this consists of applying a small but sufficient amount of molten weld metal to adjacent parts to hold them firmly in position for the final, or continuous, welding). In quite a few instances, it was found necessary to make pieces of steel to replace pieces of cast iron which could not be found. In such cases, the pieces of steel were cut to a size and shape conforming to requirements.

Arc welding of the cast iron was done in accordance with standard procedure for Lincoln "Ferroweld" electrodes, made expressly for work in cast iron.

Narrow beads—deposits of weld metal—never exceeding 3 in. in length were employed and the work was prevented from becoming too hot in order to avoid warping. Keeping the work cool by resting between welds, each bead, or weld, was lightly peened by hammer before proceeding with the next. In Fig. 1 can be seen some of the welds joining broken pieces of cast iron to the main structure of the bedplate, also the steel dowel pins holding the steel re-inforcing plate in place.

Following the arc welding of all broken pieces of cast iron back into position, steel plates were fitted to the outside of the engine bedplate and holes drilled through the plates and the cast iron. Steel dowel pins of approximately 1 in. diameter were fitted into these holes and arc welded to the steel plate and to the cast iron. A special taper at each end of the pins allowed deep penetration of the weld metal into both the steel and the cast iron. Fig. 2 shows actual welding of the bedplate.

The speed with which the welding was done by the electric arc process was reported due to the fact that with the electric arc no preheating of parts to be welded is necessary. All that is required is to shape the parts, properly fit them and finally simply fuse them together, allowing time between welds to keep the work cool.

Fig. 1. Left. Arc welds in bedplate of engine on sabotaged ship Villaperosa which was repaired in less than 2 mo. by welding as compared with at least a year to obtain replacement parts

Fig. 2. Above. The "ship's doctor" (arc welding operator) operates on the innards of the Villaperosa's engine repairing injuries resulting from work of saboteurs
(Photos, Courtesy Lincoln Electric Co.)

"Wrap" Is Important if You Want High Friction

By W. F. Schaphorst

THE accompanying sketches show clearly the importance of "wrap" if you want to create high frictional forces on drums, sheaves, pulleys, etc.

The first sketch at the left shows a rope slung around a drum and embracing 180 deg. arc of contact. That is, the belt goes "half around." The coefficient of friction of the rope on the drum is assumed to be 0.5 in the computations. Under such conditions a 1-lb. weight suspended from one end of the rope will support 4.81 lb. suspended from the other end of the same rope, due entirely to the rope's friction and to the arc of contact.

In the second sketch the rope embraces the drum 1.5 times. The same 1-lb. weight will now support 111.32 lb. suspended from the other end of the rope.

In the third sketch the rope embraces the drum 2.5 times and the weight supported jumps over 2400 lb. to 2575 lb.

And in the fourth sketch the rope is wrapped around the drum 3.5 times and the weight supported advances to the astounding figure of 59,608 lb.

Most readers have doubtless witnessed boatsmen quickly grab a rope, wind it around a drum a few times, take up the slack, and then hold a huge liner without the least rope slip unless he "wants" it to slip which he permits by easing up with his end of the rope. These figures make it clear why the boatsman's rope does not slip.

These figures also explain why a wrapper pulley is often so important on a belt drive. The wrapper pulley causes the belt to have more than 180 deg. of contact. At 180 deg., if the belt has a coefficient of friction of 0.5 a pull of 100 lb. on the so-called "slack side" will create a pull of 481 lb. on the tight side. Now increase the arc of contact still more and the effective pull will be correspondingly greater. These sketches show how rapidly the effective pull increases with increased wrap or arc of contact.

Also, this method of figuring is applicable to brake bands. The figures make clear the reason why close-fitting high-friction brake bands hold as much as they do and as well as they do.

Redeemables

By Atomizer John*

Tube Cleaner Hoses

MOST pneumatic tools are designed for 80 lb. per sq. in. air pressure at the tool. An oil tube, kinks, lubricator connection and valves along with an old oil-soaked hose may give as much as 70 lb. per sq. in. pressure drop through the hose at the volume rating of the tool. If it is desired to speed-up tube cleaning start by checking the pressure drop through tube cleaner hoses.

Tube Cleaner Motors

In modern tube cleaners the two most important parts to keep tight are the front bushing and the machine coupling. A loose front bushing will permit the rotor to wear against the cylinder or shell. A loose machine coupling will release all the parts of a motor which may result in total self-dstruction of the motor.

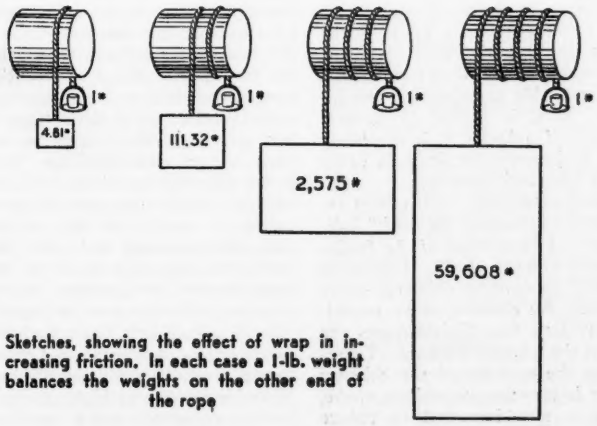
Lubrication of Tube Cleaner Motors

Every type of oil is certainly not suited to air tube cleaner motors. Parts wear can be reduced by 50 per cent in many cases by obtaining the proper oil and then instead of counting drops through the lubricator, watch the exhaust ports of the motor and see that they are always wet with lubricating oil. This is the only positive way of making sure the motor is receiving sufficient oil.

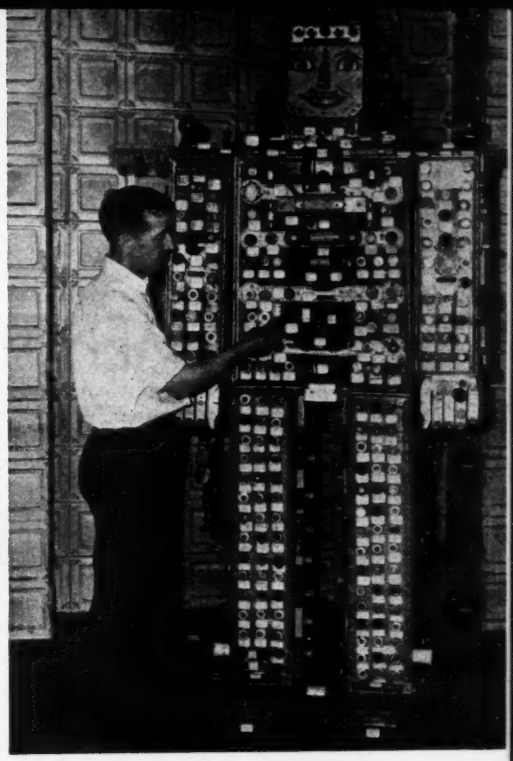
Universal Couplings

Make sure the universal couplings do not have play from wear. This alone may account for uneven drill wear, broken cutter heads, hammered front bushings and broken rotor shafts.

*An old schoolmate of Pulverizer Pete's. We went to different schools together.



Sketches, showing the effect of wrap in increasing friction. In each case a 1-lb. weight balances the weights on the other end of the rope



THE FUSED MAN

(See Page 85)

Cutter Heads

Dipping cutter heads in light oil each time they are removed from the tubes will greatly extend the life of wearing parts. (Boiler cleaners should view this with caution.)

Tube Ends

Tube ends are best prepared for rolling-in by filing them with a not too coarse file, using a rolling motion to insure roundness. A power grinder should never be used. Actually the only two reasons for cleaning the outside diameter of a proper size tube arc; one, to remove the mill scale and, two, to inspect for fractures or faults.

Tube Inspection

A 150 watt reflector-enclosed spot light makes a very effective light source for opposite end tube inspection.

Interesting Facts About Tube Cleaner Motors

The small and medium sized tube cleaners turn up to approximately 3000 r.p.m. (free speed), the medium sized motor consumes from 150 to 200 cu. ft. of 80 lb. per sq. in. air. They develop from ½ to 4 hp. The dual cylinder motors will not perform as well on low-pressure air as will the single cylinder motors.

Although tube cleaners are used extensively throughout the industries, less is known about their construction, limitations and characteristics than any other piece of common equipment. Generally the tube cleaner operators and the mechanics doing the repairs are the only ones familiar with the equipment.

LETTERS AND COMMENTS

The Chimney Question Still Smoking

THE COMMENTS by Mr. N. T. Pef on Chimneys and Smoke in the Aug., 1941, issue of POWER PLANT ENGINEERING are typical of the general lack of a clear understanding of the performance and limitations of a natural-draft chimney. This is not surprising, however, since very little information has been published on the performance characteristics of this type of pressure transformer and only a very few have the slightest idea of how a chimney performs and produces draft.

Mr. Pef states that shutting the damper of any boiler does not increase the smoke. Naturally the smoke does not increase due to the fact that the flow of gases is completely arrested and no air is being admitted to the furnace nor coal burned to cause smoke. If the setting, and all ports, are air-tight, shutting the damper increases the available draft of the chimney since there are no gases flowing to create a friction loss. When the damper is closed tightly and there are no air leaks in the system, the chimney is creating its maximum theoretical draft intensity. Shutting the damper does not create a lack of draft but a lack of capacity of the chimney.

If it be assured that a chimney is normally operating satisfactorily from the standpoint of the non-production of smoke, a gradual closing of the damper will cause the chimney to smoke due to the lack of air supply to the furnace. The degree of smoke will increase as the damper is being gradually closed until a moment or so after it has been closed tightly when the smoke will disappear altogether due to an absolute lack of air supply. Chimneys smoke because the furnace lacks a proper air supply which is regulated by the available-draft intensity of an unthrottled chimney or by the damper in the case of a throttled chimney.

Small furnaces, excess air cooling in the furnace and manner of firing, as mentioned by Mr. Pef, and a multitude of other adverse conditions, are all contributing factors towards the production of smoke but not the direct cause. It is not reasonable to assume that a small furnace, or excess air cooling the furnace, or the manner of firing, or other similar conditions are the main cause of smokey chimneys. There are too many well constructed and well operated plants in operation throughout the country which still produce objectionable smoke to disprove that argument. All of these conditions can be remedied by proper construction and operation and are beside the main point in the discussion that the chimney is the worst offender in the production of smoke.

Mr. Pef also states in the last paragraph of his letter that "it is all right to add stack height or install fans to increase the capacity of your boilers but if your boilers smoke you cannot reduce the smoke by increasing the draft." It is most difficult to reconcile this statement with the fact that the addition of height to the stack, or the installation of a fan, to increase the boiler capacity, also increases the draft available for the installation. If height is added to the chimney, or a fan is installed as an auxiliary, what becomes of the draft which these two draft producers create? They most certainly augment the draft created by the existing chimney. The addition of extra height to a chimney, or the installation of either a forced draft of an induced fan to operate in conjunction with a chimney, is similar to installing a booster pump to operate in conjunction with an existing pump. These added auxiliaries increase the draft available for the installation and as a consequence also add available capacity for the installation. If it is desired to increase the capacity of a boiler, it is absolutely necessary to increase the draft in order to get this increased capacity.

For one to state that "you cannot reduce smoke by increasing the draft" indicates a lack of knowledge of the fundamental principles of draft. Increasing the draft of an existing chimney, either by extending the chimney or by providing an auxiliary fan, also increases the capacity of the existing chimney. Therefore, when the capacity of the chimney and boiler is increased to reduce smoke, the draft is also increased to reduce smoke. The relation between draft and capacity of a chimney, an extended chimney, a fan, or a fan operating in conjunction with a chimney follow certain principles which are constantly related. In order to reduce smoke by providing more capacity for the chimney and boilers, it is absolutely necessary to increase the draft of the chimney. There is no other way to provide more air for the furnace.

Indianapolis, Ind. J. G. MINGLE

I Took the Job at Glendale

IN THE Spring of 1940 it became a little evident that due to a combination of circumstances the local utility at which I was the Chief Steam Plant Operator would not greatly expand and I was left with the prospect of being at least 5 to 6 yr. in a "static" condition. To some this situation of easy steady operation is desirable but being rather young, I wanted a job that would need continuous enterprise. I was to find out that I was not alone in this desire because all but two of the final crew came for the latter reason alone. The oldest man was 39, the youngest 23. Also the weather conditions at the old job were not the best and while far from perfect, the Glendale weather looked better on paper. The possibility of making new and more contacts, adding responsibility, and what looked like enough increase in salary to pay for the move, all had a bearing on the application. It was hoped that enough could be saved on the first year to make up the less in equity on my house and the cost of moving, etc.

The city of Glendale is not the Garden of Eden that the Chamber of Commerce would have one believe, but it is pretty. Nestled in and around some mountains that rise over 4000 ft. and that are almost perpetually green, it is very attractive. There are 80,000 people of which sixty per cent live on money made in Los Angeles. Los Angeles almost surrounds Glendale and refers to the latter as its "bedroom". It has a very meager shopping district, few tourist courts, only two hotels of any size, fair school buildings (so called progressive system that is fast losing favor with the mamas and papas), lots of churches, and theatres. Except for the low flying airplanes the town would be very quiet. Many of its people are retired and there is a constant campaign against noise, night life, house parties, and gayety. There seems to be some kind of an unwritten law forbidding house entertaining, so the boys and girls of high school age are accustomed to riding to outside the city to blow off their excess energy and pep. One may not wine, dine, and dance in the same establishment in Glendale. It was my observation that to save the joyous laughter of school kids from bothering the neighborhood, the people of Glendale had created two of the "fastest", and least desirable morally of high schools. There is little to attract young couples to the

city except the airplane boom, for there is nothing for them to do, and the older, higher paid, group that predominate cause rents to be high as well as most other items. Even such pleasures as "night" soft ball in supervised parks brought down a riot of protest from those who had "retired" (in more ways than one). By law, ordinance, custom, or some means Negros are discouraged from living in Glendale. Even Negro servants are usually out of town by dark. But thou shalt be quiet in Glendale.

The job was a perfect set up. Being 3 miles away from the administration office, the plant was not hampered, dictated to, or haggled by the political gentry. The population all more or less working in Los Angeles, reading L. A. papers, and coming home only for rest and quiet, were not continually harping, nor much interested. Many of the town people do not know where the plant is nor do they care. A few months of operation was done with the construction crews under foot, and made it a little hazardous and inconvenient but was expected. There were only three main non-operating troubles with other departments; the city had never had a plant before and the accounting and purchasing was not set up to handle emergency orders as became necessary, the mens' time went through about four or five hands and there was some difficulty in getting the men paid correctly, and the load conditions have not been such as to warrant a full crew so consequently the administration has leaned over backwards to keep from getting too many operators (this has made it awkward at times of illness). The administration is strictly on the level, and this is meant literally. A more honest, conscientious, lover of the city than the superintendent could not be found. He lives Glendale first, last and always. The power plant was paid for in cash out of savings in his department and did not necessitate a bond issue nor cause any indebtedness in any way. So will it be with the new unit just ordered. As for a crew, they came mostly from the West. All had worked with steam turbine plants and boilers, five had worked in central stations, the regenerative cycle was new to some as was condensers and electrical generation. All are good hard workers, ambitious, and there was no trouble getting the men to rotate jobs until now every man knows the plant from top to bottom, boiler to switchtrack. The mechanical troubles, while they seemed big at the time, have been trivial. The feed pumps, heaters, cooling tower, and draft fan couplings cause the most concern, but there have been only two forced emergency shut-downs, which is thought to be very good for a new plant and tions at this plant that have been interesting such as the outdoor turbine, a new crew. There are a few innovations that have been interesting such as the outdoor turbine, the hydrogen cooling (new on the Pacific Coast), and the floating boiler pressure which is limited only by the feed pump's ability to pump. It is a plant of smooth operation, and except for waste space it is of practical design, has room for future expansion, and has good equipment.

Yet withall I am leaving for the following reasons: power plant operation is a means to an end; this plant is a little ahead of its time and continuous operation is some distance away, in fact, it may always be seasonal; should the defense boom cause a major depression, the plant may shut down; a beautiful opportunity came to fill some gaps in my experience schedule that could not be overlooked.

In general if it had not been for the tremendous rise in the cost of living (which was according to the C of C figures about 27 per cent since Jan. 1, 1941) all of the losses of moving would have been made up, a better car had, as well as the extra amount of insurance. This is a better place to live even if the California weather went wrong and gave 30 in. of rain in 2 mo. last spring. Valuable contacts were made, in fact gave the opportunity for the new position. Working for a municipality with civil service is not as bad as might be imagined. One turbine operator had a better job offered already, a "watch engineer" has been given a good chance at the vacated "Chiefs" position, and a "boiler operator" has put himself in line for a "watch engineers' job. The opportunities have been good, and it is believed that every one on the job would repeat their choices. There is no wailing.

BILL MADDOCK, M. E.

HE TOOK THE JOB AT GLENDALE

In July, 1940, we directed attention to the fact that the City of Glendale, California, was holding civil service examinations in an endeavor to secure a competent operating engineering staff, but that there seemed to be little interest in the job on the part of engineers throughout the country. We were curious about this lack of interest in what seemed to be a good job, so we put the proposition in the form of a problem in the "How Would You Do It" Section. (See p. 82, July, 1940, issue.) The response to this request for opinions about civil service jobs was gratifying and we received many fine letters, a number of which were published. It was quite evident from these letters that there was an aversion on the part of operating engineers to civil service jobs—they do not like to work under political domination and they seem to feel that civil service jobs do not offer sufficient opportunity for promotion. ¶ All this was a year ago and we thought we had said all there was to be said in the matter and had pretty well forgotten about it. Now, however, interest in the subject is suddenly revived by the receipt of this letter from Bill Maddock. Bill Maddock, it will be noted, took the job as chief engineer at Glendale, but now, after less than a year he is leaving. In view of the opinions expressed on this subject last year, it will be interesting to know what the circumstances surrounding the job were. In this letter he tells us. 1. Why a change was wanted. 2. Facts about the City of Glendale. 3. Something about the job, and 4. Why his resignation was submitted after one year. Comments on his experience and his reaction to it will be welcomed.

Safety Notes

A NEWLY hired lineman on his first day was stringing in a third wire on a 13,000 v. circuit in order to convert the line from single phase to 3-phase power. (This is a 13 kv. grounded system.) He was standing on a crossarm and was getting ready to tie the dead wire on to the pole top insulator. Of course, the two outside phase wires were hot. When he leaned over to pick up the wire from the crossarm he stuck his left foot out in order to balance himself and it came in contact with the hot wire. He lost three months' time and it is probable that his arm may remain stiff since the current burned the leader in his elbow.

The report states the workman was careless in his actions and should have had the hot line covered with a pig. He should also have been using rubber gloves. As a result of this accident consideration is being given to applying a penalty to men who fail to cover up hot wires and who do not wear rubber gloves when they are within reach of hot conductors.

It would also seem that closer supervision particularly of a new man on such work might have been expected.

* * *

In another case, a man cleaning and inspecting station transformers crawled into an empty transformer tank to clean it with a mixture of gasoline and carbon tetrachloride. The evaporation of the cleaning solvent forced all oxygen out of the tank and the employee become unconscious. He recovered and, as a result of this accident, further emphasis is being placed on the practice of ensuring proper ventilation when using cleaning solvents.

Questions And Answers

133

What Is a Double Ported Expansion Valve

Q. C.W.P. wants to know what a double ported expansion valve is, how it works and what advantages it has. Can someone give him this information?

134

How Can He Regulate His Blowback?

Q. How can I control the amount of blowback on my safety valves? In the operation of our safety valves, the blowback is from 9 to 18 lb. I have the regulating ring screwed way down to its limit but still have the same blowback. What could be the reason for this and what steps might I take to remedy it?

Brookway, Pa. JOHN FREMER.

135

Cleaning Boiler Tubes

Q. What is the proper method of using an air driven tube cleaner for cleaning boiler tubes? Should you let it automatically feed its way in or should it be worked in backward and forward overlapping a little each time?

We are using a cleaner using an air driven motor in a swing frame head. The tubes we are turbining are 4 in. in diameter by 20 ft. long. Any information anyone can give me on the correct use of such equipment will be appreciated.

Washington, D. C. HOMER HULSEY.

136

Burning Wood Waste on Stokers

Q. We have a plant with two boilers (250 lb.) fired by underfeed stokers. These boilers have always been fired with coal, but recently because of a change in manufacturing operation a large amount of wood waste has become available, and we have been thinking of burning it under the boilers. Would it be possible to burn this on the stoker grates by just feeding it in at the side of the furnace? The wood consists mostly of shavings and sawdust with some larger pieces. We do not want to redesign the furnaces since the availability of the wood waste cannot be assured. Any information based on the experiences of others in this respect will be appreciated.

Athol, Mass. H. G.

A. 96

Further Advice on Making Manhole Plates Fit

A. In Question 96, D. H. W. tells of his troubles in making his manhole plates fit. Leaky gaskets, both handhole and manhole, have been the bane of every operating engineer's existence since boilers were first developed. Why? Because the man in the field simply puts up with it and accepts it as "one of those things." Some few men have shown enough interest in the problem to tackle it and have succeeded in solving it. We can dismiss handhole plate leaks because with the advent of the key caps this bothersome problem has been practically eliminated. What about the manhole gasket leaks—here is another story altogether.

Since we are dealing with an H. R. T. boiler at the present moment, it might be well to see what the "code" requires as to manhole openings. We will assume a pressed in manhole opening.

The code requires the manufacturer to meet certain minimum requirements concerning the manhole opening in a boiler, i.e., a minimum width of $\frac{11}{16}$ in. bearing surface for a gasket is required on a manhole opening. An H. R. T. boiler of the size mentioned (72 in. x 14 ft.) would have a minimum head thickness of ½ in., therefore to comply with the code requirements for width of bearing surface for a gasket a band or ring of steel is usually shrunk on the flanged in section of the opening. This band is generally ⅛ by 1½ in. strap iron and is usually held in place by dowel pins or welded in. The surface of the opening is then machined to insure a perfect fit with the gasket and the plate. The reason for the code requiring this minimum bearing surface must be obvious. Now then sometimes these bands become loose in service or the surface is cut or grooved; in either case the band must be made tight and the surface trued up again before replacing the gasket and the plate.

There are several types of cover plates in use but the most extensively used plate is of a pressed steel type with pressed steel arch bars or dogs. The advantage of this type of plate is that it is lighter than any other form and it is cheaper to manufacture. The usual plate is ½ in. thick with two 1¼ in. bolts, the bolts being either fixed or movable depending on the design. The plate may be convex or have several pressed "waves" in it. Due to the method of fabrication, loose dies, sloppy fit and an "I don't care attitude" on the part of the pressmen, these plates have a peculiar disadvantage all their own; this disadvantage is a lack of sufficient provision for holding in the gasket at its outer edge, and hence the gasket is liable to be blown out or dislodged enough to produce leakage under high pressures. It will also be noted that the plate as designed (½ in. thick) is safe as far as stress conditions are concerned, but how about the practical conditions that will be encountered in its use? Again the question may arise as to the proper gasket to be used with a certain plate.

Let's see what actually takes place when a manhole plate is placed in service: we will assume that the head gasket surface is true—that the plate surface is true and that a standard type of gasket is used. When D. H. W. first tightened up his plate after installing a new gasket, the joint was tight for several weeks and then it began to leak and on further tightening the leakage became worse.

The plate upon the first tightening was subjected to a light strain—enough to slightly compress the gasket to prevent leakage. As pressure was raised on the boiler the gasket was further depressed and the plate was deflected a little (check this with a dial micrometer) with the compression of the gasket coupled with a loose fitting plate in the opening the plate had a tendency to move, and so with the constant raising and lowering of the steam pressure and the subsequent heating and cooling of the boiler the movement of the plate was sufficient to cause the breaking of the bond that had been originally established between the plate and the gasket. Leakage then developed and the normal reaction to leakage is to tighten up the object. D. H. W. did this and to his chagrin the leakage became worse. Why?

In the first place the gasket had been compressed to its limit and was, therefore, useless as a gasket; secondly, upon tightening up the plate the second time the plate was deflected to such an extent that the normal parallel planes that exist between plate and head were destroyed beyond repair. Thus the leakage was merely aggravated instead of helped.

To remedy the situation the manhole plate must meet several practical requirements which are: first, the plate must be sufficiently strong—thick—to resist the deflection moment, in other words it must not bend under the strain that it will be subjected to; second, the plate must be so designed to provide a maximum retaining edge for the gasket —this is important because this edge must present a square surface at right angles to the gasket for a distance of at least ¼ in. (this is required since the code prohibits the use of a gasket having a thickness greater than ¼ in. when compressed) to prevent the gasket from crawling up between the plate and the opening. The plate must also fit the opening to a very close tolerance. This is essential in order to keep the gasket from squeezing out between the plate and the opening. Never use an ill fitting plate, one that practically floats around in the opening. This in itself is the chief cause of leaky manhole cover plates. Use a

good heavy plate, well designed and one that snugly fits the opening and your leakage troubles will be over.

Williamsport, Pa. K. A. PIPPART.

A COAT OF GRAPHITE AND CYLINDER OIL WILL HELP

A. D. H. W. states that in trying to remedy the leaking he had the manhole plates trued up. The manhole frame gasket seat should have been trued up at the same time and by the same workman.

I suggest the following to D. H. W. Does the bolt in the manhole plate form a right angle with the horizontal line of the plate? If not, the bolt should be straightened or a new one installed. Otherwise, when the plate is pulled up it will be slightly off center, this is sufficient to cause leakage. The gasket seat should be inspected for pits or grooves. If either the manhole plate or frame have pits or grooves in them, the local state or insurance inspector should be called in and his suggestions followed. The gasket should be of the proper size and thickness. A coating of graphite mixed with a small amount of cylinder oil will help materially to prevent leakage. This coating should be applied to both sides of the gasket and to the seat. Red lead may also be used for this purpose. It should be applied in the same manner.

Finally, the dry sheet under the manhole should have a 1 in. hole drilled in it so as to drain off any leaking water. The plate and ring should be chisel marked before removing. The marks can then be used for reference when replacing the plate. The air cock should always be opened after a boiler has been cut off the line. The drop in pressure is sufficient to cause leakage around the gaskets of manhole plates when steam is again raised.

TYLER G. HICKS.

New York, N. Y.

A. 111

Making a Low Voltage Transformer

A. In response to Mr. Laughinghouse's request I am submitting the following information on the design of a transformer to deliver 160 volt-amperes at 4 v. when connected to a 110 v. 60 cycle supply.

E = The effective voltage corresponding to N turns

B = Flux density in lines per square inch

A = Net area of core in square inches

N = Number of turns

F = Frequency

$$E = \frac{4.44\ BANF}{10^{-8}}$$

$$\frac{E}{N} = 1/40\ \sqrt{160} = 0.316 \text{ v. per turn}$$

$$A^1 = 6.45 \times \frac{E}{N}$$ in which A^1 = gross area of core

Then $A^1 = 6.45 \times 0.316 = 2.038$ sq. in. gross area of core

Width of core $= \sqrt{2.038} = 1.427$ in., say 1.5 in.

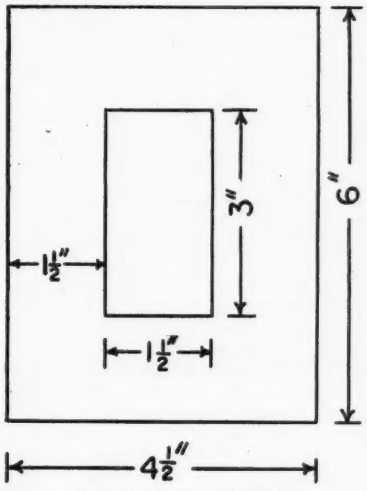
Number of turns in 4 v. winding

$$\frac{4 \text{ v.}}{0.316 \text{ v. per turn}} = 12.7, \text{ say } 13 \text{ turns}$$

Number of turns in 110 v. winding

$$\frac{110 \text{ v.}}{0.316 \text{ v. per turn}} = 348 \text{ turns}$$

$$\text{Current in 4 v. winding} = \frac{160 \text{ v.a.}}{4} = 40 \text{ amp.}$$



Proportions of core window

$$\text{Current in 110 v. winding} = \frac{160}{110} = 1.46 \text{ amp.}$$

Circular mils required for 4 v. winding,

1000 mils per amp. × 40 amp. = 40,000 C.M.

Circular mils required for 110 v. winding,

1000 × 1.46 = 1460 C.M.

The low voltage winding would require No. 4 A.W.G. at .204 in. diameter. The high voltage winding would require No. 18 wire A.W.G. enamel single cotton covered .0477 in. diameter.

The windings should be insulated from the core by at least $\frac{1}{16}$ in. with strong paper and have ⅛ in. keep back. The insulation between windings should be $\frac{1}{16}$ in. and a thin sheet of paper between layers. The low voltage winding placed next to the core.

For good proportion the window should be about 2.5 W × 1.5 W, where W is the width of the square core in inches. (See diagram.)

The length of winding including keep back should be ¼ in. less than the height of the window opening.

The actual length of winding space will be 2.5 W — ¼ in. — (2 × keep back).

Assume length of window opening of 2.5 W = 2½ × 1½ = 3.75.

Turns per low voltage layer =

$$\frac{3.75 - ¼ - (2 \times ⅛ \text{ in. keep back})}{.204 + 10\% \text{ allowance}} =$$

$$\frac{3.25}{.224} = 14.5, \text{ say } 15$$

Since only 15 turns are required they can be wound in one layer.

Turns per high voltage layer =

$$\frac{3.75 - ¼ - (2 \times ⅛ \text{ in. keep back})}{.0477 + 10\% \text{ allowance}} =$$

$3.25/0.0524 = 62$

Number of high voltage layers = 348/62 = 5.6, say 6

With a 2 legged core type transformer with a coil wound on each leg, the total thickness of each is made up as follows:

Insulation between core and low voltage	.063 in.
Low voltage winding, thickness 1 layer	.224 in.
Insulation between high and low windings	.063 in.
Total	.350 in.

High voltage winding =

3 layers × .058	= .174
2 layers insulation × .04	= .08
	.254 in.

Total thickness of coil is .350 + .254 in. = .604 in.

Width of opening of window = (.604 × 2) + insulation thickness .25 in. = 1.458, say 1½ in.

The average length of turn of high voltage winding is

$$2\pi\left[\frac{W}{2} + \text{core to L.V. Wdg.}\right) + \text{(L.V. Wdg. thickness)} + \text{(H.V. Wdg. to L.V. Wdg.)} + \text{(½ H.V. Wdg. thickness)}\Big] = 2\pi\left[\frac{1.5}{2} + .063 + .224 + .063 + \frac{.254}{2}\right] = 7.719 \text{ in.}$$

Total length of conductor for high voltage winding = 7.719 in. × 348 turns

$$= \frac{2686.5}{12} = 224 \text{ ft. not including leads}$$

The resistance of No. 18 wire is 7.76 ohms per 1000 ft. at 75 deg. C.

Resistance of high voltage winding is

$$224 \text{ ft.} \times \frac{7.76}{1000} = 1.738 \text{ ohms}$$

I^2R loss in high voltage winding = $1.46^2 \times 1.738 = 3.7$ watts.

Weight of No. 18 A.W.G. single cotton covered is 5.13 lb. per 1000 ft.

$$233 \text{ ft.} \times \frac{5.13}{1000} = 1.2 \text{ lb. nearly.}$$

The mean length of turn of low voltage winding is

$$2\pi\left[\frac{1.5}{2} + .063 + \frac{.224}{2}\right] = 5.82 \text{ in.}$$

Total length of low voltage winding = 5.82 in. × 13 = 75.66 in. or 6.3 ft. not including leads.

Resistance of low voltage winding = .001736 ohms at 20 deg. C.

Weight = 1 lb., nearly.

I^2R loss = $40^2 \times .001736 = 2.8$ watts.

Total I^2R loss = 3.7 + 2.8 = 6.5 watts.

The window is 3 by 1½ in. and the iron section is 1½ in. square.

Gaylord, Mich. O. J. PIERSON.

A. 116

Preventing Corrosion of Copper Switches

A. In answer to your June issue of POWER PLANT ENGINEERING wherein B. H. W. wishes to know how to prevent corrosion on copper switches and electric circuit breakers, I wish to state a simple method. Some engineers or maintenance men have used a little graphite mixed with petroleum jelly, but I find that pure vaseline (enough to moisten blades) is about the best remedy and does not have to be applied so often. If you try this method I'm sure you will be pleased with the results.

ROWLAND BALMER.

Philadelphia, Pa.

A. 117

Use of Steam in Atomizing Burners

A. In answer to Mr. Edward H. Goebel's request in the June, 1941, issue of the Practical Engineer, let me hurriedly advise him not to throw his oil away just yet, as steam is pretty much of a negative substitute for fuel.

The admission of steam serves to more finely atomize the oil, thus usually resulting in shorter flame propagation and more complete combustion in the furnace. In other words, it will tend to reduce the carbon loss, and therefore increase the over-all efficiency by approximately this reduction in carbon loss.

With respect to combustion, every substance that is capable of burning or oxidizing has what is known as heat value. Every substance combined with a maximum amount of oxygen has what can be called heat of dissociation. In accordance with the law of conservation of energy, it follows that if 1 lb. of carbon, for example, burns to CO_2 and gives up 14,600 B.t.u. of heat, then it requires at least 14,600 B.t.u's of energy to separate or dissociate CO_2 back to carbon and oxygen.

One pound of steam at say 150 lb. saturated has 1195 B.t.u's of heat in it. If hydrogen is burned to H_2O it gives off about 6900 B.t.u's to produce 1 lb. of water. The heat of dissociation of water is therefore at least 6900. One pound of steam at 150 lb. having 1195 B.t.u's would require at least:

$$6900 - 1195 = 5705 \text{ B.t.u's}$$

to separate the steam into its elements.

The steam entering the furnace with the oil dissociates, as Mr. Goebel says, at about 2200 deg. F. furnace temperature, but it takes 5705 B.t.u's from the heat liberated by the oil to break up 1 lb. of the steam into hydrogen and oxygen. Then as the temperature reduces in the region near the boiler tubes, the hydrogen again combines with the oxygen and gives the 5705 B.t.u's back to the furnace. The net gain in heat from the steam in the furnace is zero. Furthermore, no dissociation would have occurred if the heat from burning the oil were not there to do it.

There is a slight heat loss due to the addition of steam to the oil if the temperature of the flue gas leaving the boiler is more than the temperature of the steam entering the furnace. It is obvious if the temperature of the steam entering with the oil is 365 deg. and the temperature of the flue gases carrying this steam with it is 600 deg., the steam is carrying more heat away than it put into the furnace. This is a negligible quantity, however, since the percentage of steam in the flue gas is usually less than 1 per cent.

Since there is no gain in efficiency due to dissociation of steam in the furnace, and practically zero reduction in heat loss at the stack due to the atomizing steam, it follows that the only gain in efficiency must be due to reduced carbon loss.

MARVIN A. SAYLAND.

Seaford, Del.

BURNING WATER IS SHEER NONSENSE

A. It can be said at the start that nothing can be gained by splitting up water into oxygen and hydrogen and burning them to form water again. This clearly is a reversible process and should, theoretically, entail little loss, but, in boiler practice, hydrogen and oxygen burn to H_2O in the form of steam which goes up the chimney carrying with it all its latent heat and some of its sensible heat, thus entailing a loss of considerable magnitude.

The same thing happens when the fuel itself contains hydrogen and this loss is generally referred to as the "hydrogen loss."

A well designed mechanical pressure oil burner is perhaps as efficient as anything of the kind on the market when operating at full load, but, as a rule, it does not give efficient atomization over a wide range of load. It is true that there is one type on the market for which high efficiency over a wide range is claimed, but even this has its limit.

It is difficult to see how a well designed mechanical burner, with oil at optimum temperature, or perhaps we should say at optimum viscosity, and a satisfactory load, can be made to operate better by the injection of steam, although it is true that when operating over a wide range of load steam atomizing burners often prove to be the more efficient.

It is quite conceivable that the operation of a mechanical pressure or similar type of burner which does not give satisfactory atomization might be improved by the injection of steam, not only through improved atomization but through a more intimate mixing of the air.

The whole question boils down to this: Will the better atomization and better mixing, due to the injection of steam, more than compensate for the losses due to the steam itself? Possibly in some cases they may, but it is doubtful whether, except where the atomization or turbulence is very unsatisfactory, there can be any net gain, and there may well be a considerable net loss.

With regard to the rapidity of ignition, there is no doubt that steam has an inherent tendency to delay ignition, owing to the refrigerating effect of expanding steam, at the same time it is quite possible that a more rapid mixing of oil and air may more than compensate for this, so it is difficult to generalize as to whether this condition might be improved by the injection of steam. It may, however, be definitely said that any suggestion that a gain can be made by an attempt to burn water is nothing but sheer nonsense.

JAMES O. G. GIBBONS.

Bloomfield, N. J.

A. 118

There Are Some You Can't Smell

A. In the June issue Mr. Altman asked a very interesting question, your No. 118. Some of the organic refrigerants which do not have an odor and the carbon dioxide are very hard to detect and leakage losses are apt to be heavy.

Freon (F-12) is best tested for by a blow torch using alcohol instead of gasoline. The torch must be adjusted to give a colorless flame. In the presence of Freon this flame becomes a blue green color. This color will be noticed, therefore, at any of the joints which leak. The color might be quite fleeting and considerable care must be exercised to catch the color. Any dust in the air masks the blue green color by producing a yellow flame.

Carbon dioxide is the hardest refrigerant to test for chemically. One way of determining leaks is to add peppermint to the refrigerant. This will impart an odor which may be distinguished. Another way is to paint the suspected joints with soap solution. Bubbling, of course, indicates leakage.

Sulphur dioxide is one of the easier ones to determine. The odor of the material is quite a delicate test in itself. A better way is to moisten blotting paper with aqua ammonia and when this is brought near a leak, the white smoke characteristic of the sulphur dioxide is developed.

Methyl chloride is another hard refrigerant to determine. Here again one of the best ways is the addition of a substance imparting an odor to the refrigerant. In this case acrolein is recommended. The alcohol flame may also be used as it disassociates the chlorine compounds giving the blue green color to the flame.

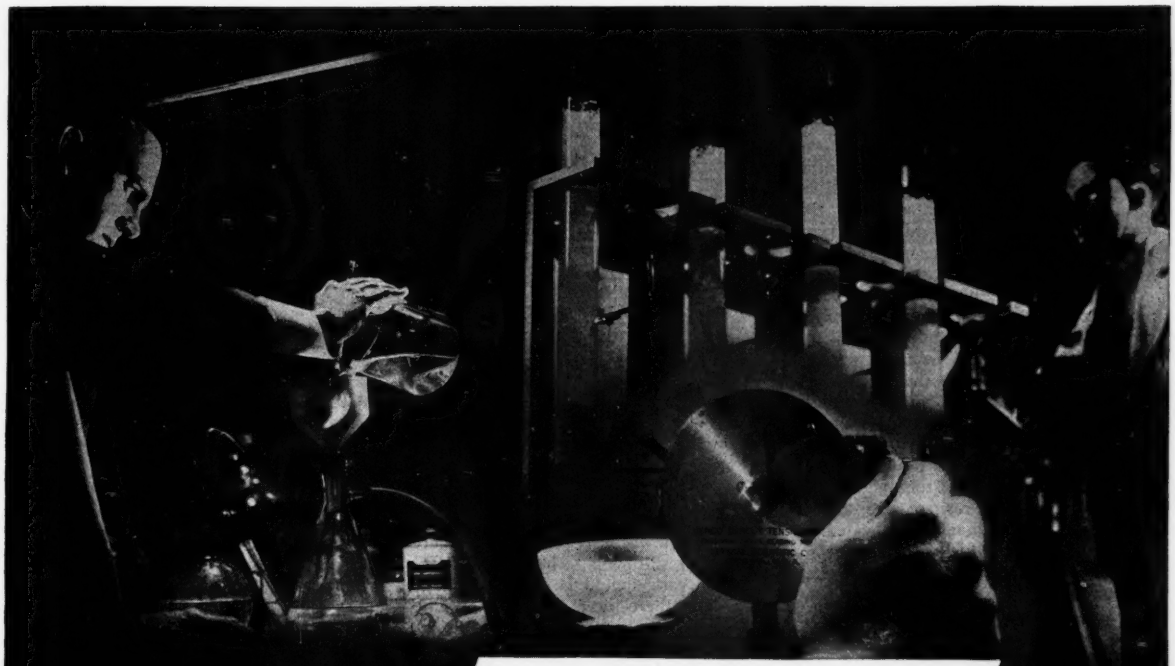
For ammonia, the sulphur candle or taper is the simplest test. The smoke produced by burning sulphur in the presence of ammonia fumes is very pronounced. Litmus paper may also be used as ammonia will turn red litmus paper blue.

Ethyl nitrite is sometimes added to the odorless and colorless refrigerants and where leakage occurs this chemical will turn starched iodine paper blue.

Lakewood, Ohio. J. P. SIMONS.

OTHER METHODS IN GENERAL USE

A. In answer to Mr. Altman's question, No. 118, in the June, 1941, issue of POWER PLANT ENGINEERING, the following methods of gas detection are in general practice:



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Sulphur dioxide is easily detected even in very small quantities by its smell; it has the characteristic pungent smell of burning sulphur. To localize a leak, it is only necessary to moisten a rag with aqua ammonia (the household variety will do), and pass it near the area suspected of leaking. The sulphur dioxide, upon coming in contact with the ammonia, will form a white cloud of smoke; the cloud increases in density upon nearing the leak.

Conversely, in the case of an ammonia leak, a source of sulphur dioxide, such as a burning sulphur stick, will indicate immediately the source of the escaping ammonia by the characteristic white cloud of ammonium sulphate. To detect ammonia leaks into brine, a test using Nessler's reagent is employed. The brine under consideration is placed in a glass beaker or test tube and a few drops of Nessler's reagent are added. The presence of ammonia is indicated by a yellowish color, which varies in depth according to the quantity of ammonia present. Nessler's reagent may be prepared by any competent pharmacist.

It is a well known fact of chemistry that compounds containing chlorine will tinge a colorless gas or alcohol flame green. Refrigerating engineers use this principle to detect leaks in Freon (F-12, dichlorodifluoromethane) and methyl chloride charged systems. To test for Freon, etc., it is customary to use the specially designed "halide torch". The halide torch is a small alcohol blow torch which has a long, flexible rubber tube connected to the air supply of the burner. It is then obvious that the air required for the proper combustion of the flame, must first pass through the exploring tube. Any gases present in the atmosphere near the end of the rubber tube will be drawn into the flame along with the air supply, and they will color the flame green if they have chlorine in their composition. Since both methyl chloride and Freon are practically odorless, systems containing these gases should be carefully checked to prevent leaks.

Carlsbad, Calif. ALAN KNOX.

137

Welding Precautions

Q. What are the usual methods used in welding practice to make certain that tanks having contained inflammable substances are free of dangerous vapors and gases? M. W.

Chicago, Ill.

A. The methods generally used vary somewhat with the nature of the materials involved and the circumstances under which the work is done. Where steam is available, it can be used to remove materials which are easily volatile. Washing with a strong solution of caustic soda or similar chemical will remove heavier oils.

Even after thorough cleansing, the container should, wherever possible, be further safeguarded by filling it with water before any welding, cutting, or other hot work is done. In practically every case it will be found possible to place the container in such a position that it can be kept filled with water to within a few inches of the point where welding or cutting is to be done In doing this, care should be taken to make sure that there is a vent or opening to provide for the release of heated air from inside the container. This can usually be done by opening the bung, handhole, or other fitting which is above water level.

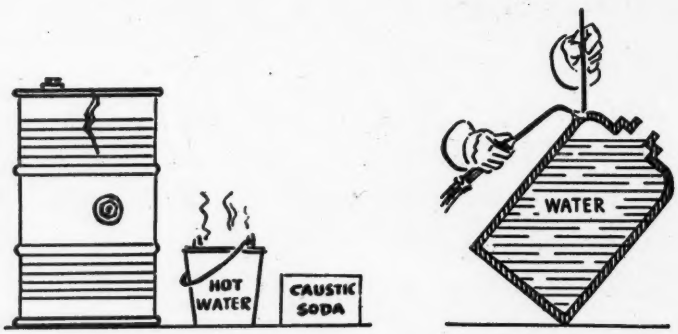


Fig. 1. Right—Containers which have contained flammable materials should be filled with water before welding or cutting. Make sure the space above the water level is vented. Left—The recommendations given in the text should be followed closely when working on containers

Where it is not practical to fill with water, carbon dioxide or nitrogen may be used in the vessel for added protection. Periodic examination of the gas contents of the vessel or container should be made from time to time to make sure that the concentration of carbon dioxide or nitrogen is great enough to prevent the occurrence of a flammable or explosive mixture. The air or air-gas mixture inside any containers can be most easily tested by using a suitable gas detector. If a gas detector is not available, a gas sampler can be used.

The carbon dioxide concentration should be at least 50 per cent in the air space inside the container, except that if the presence of hydrogen or carbon monoxide is detected, the carbon dioxide concentration should be 80 per cent or more in the free space. If nitrogen is used, the concentration must be at least 10 per cent higher than the concentration specified for carbon dioxide.

The reason for using carbon dioxide or nitrogen in an apparently clean container is that there may still be traces of oil or grease under the seams—even though the vessel may have been cleaned and flushed with caustic soda solution. The heat of the welding or cutting operation may cause such oil or grease to give off flammable vapors to the extent that an explosive mixture may be formed inside the container. *Precaution:* The use of carbon tetrachloride in place of carbon dioxide or nitrogen is not recommended as carbon tetrachloride gives off a poisonous vapor when heated.

Make sure that jacketed containers or other hollow parts are sufficiently vented before heating, welding or cutting. Remember that air or any other gas which is confined inside of a hollow part will expand greatly when heated. The internal pressure created may be sufficient to cause the part to act like a bomb.

A metal part which is suspiciously light is hollow inside, and should be drilled to vent it before heating. Every possible precaution should be taken with jacketed vessels, tanks or containers to vent the confined air sufficiently before doing any hot work.

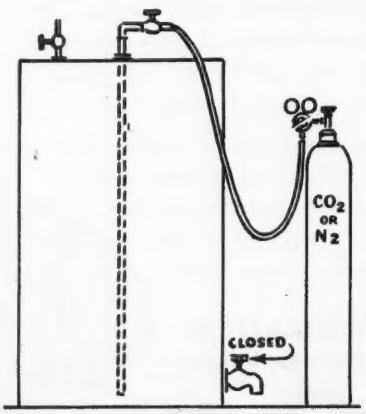


Fig. 2. Suitable concentrations of nitrogen or carbon dioxide may be used to supplement thorough cleaning to safeguard containers

A. 124

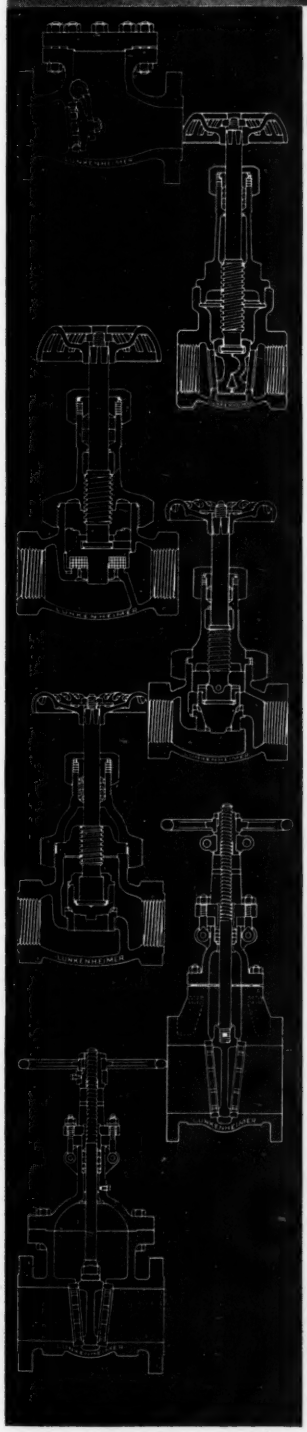
Advice on Stoker Control

A. In answer to W. C. Zinn's question I would like to state that the change from the 5 to 1 differential to the 5 to 3½ is the better and I think most economical.

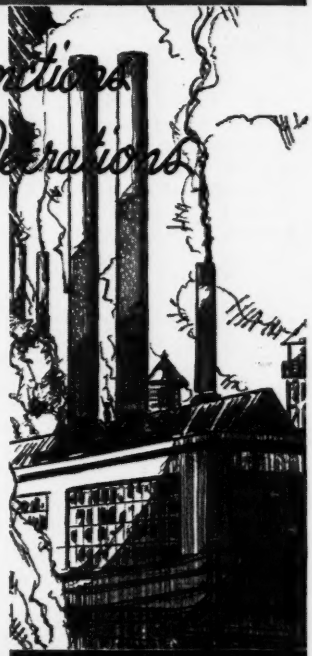
In dropping from 5 lb. back to one causes uneven furnace temperatures and greater condensation in the lines that have to be overcome before the pressure starts to rise again. In the 5 to 3½ differential the furnace has had less chance to cool off, there is less condensation in the lines. While the stoker might operate more times per hour, it will be on less time per operation. On an oil burner system I have a hook-up that has a 105 to 98 lb. diff. The burner depends on the furnace walls for ignition and while the burner operates more times per hour, it is on only about 20 per cent of the time from one operation to another.

Baltimore, Md. CHAS. W. PARKS.

LUNKENHEIMER VALVES



Perform important service functions in support of Defense Operations



It's quite natural when thinking of Defense to picture large plants — thousands of machines — and legions of men all busily engaged in the production of munitions, tanks, armored tractors, ships, airplanes and similar war units.

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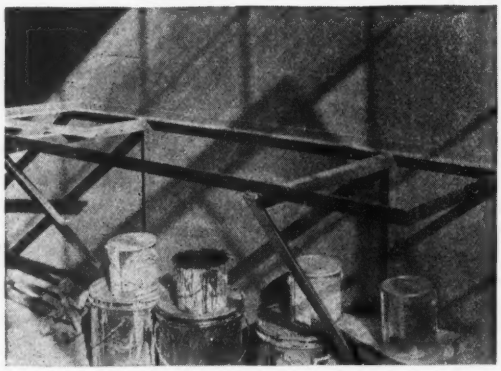
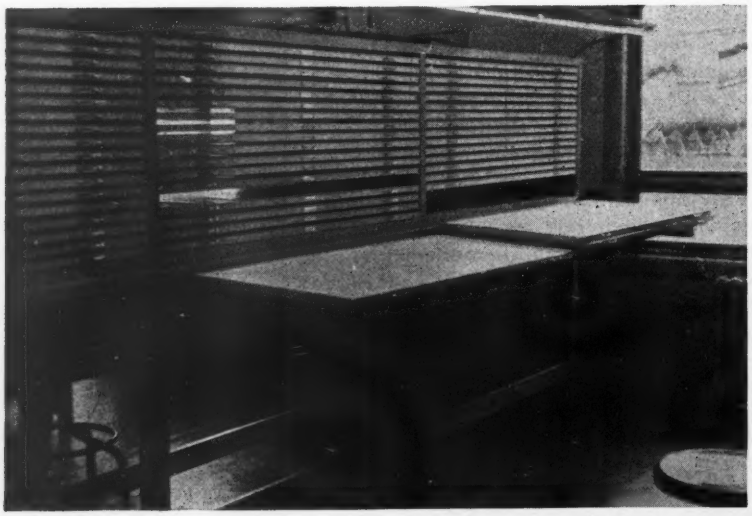
SHOP TALK

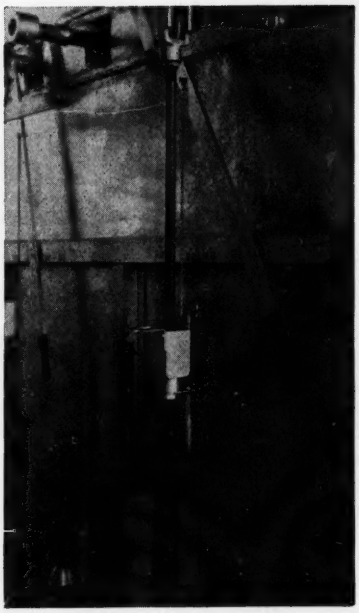
A department showing by means of photographs how engineers in various plants have overcome certain obstacles or devised methods to facilitate operation. If you have done something along similar lines that you are proud of or which you feel may be of interest to others, send us a picture and a paragraph of explanation. If the photograph is good and if the idea is original we will present it on this page and pay you for it.

WORK TABLES—Always convenient, suitable work tables are often at a premium in the plant, and this photograph shows how the problem was solved at the Hobart Mfg. Co. at Troy, O. Located behind a new boiler the table frame is made of welded angle iron securely anchored to the cement wall. Two inch planks fit the angles nicely and make a solid practical table. The absence of vertical legs provides a clear space underneath for storage of material if necessary. It is adviseable to cast plates or bolts in the concrete. This, however, is not always as practical as drilling anchor bolt holes later.

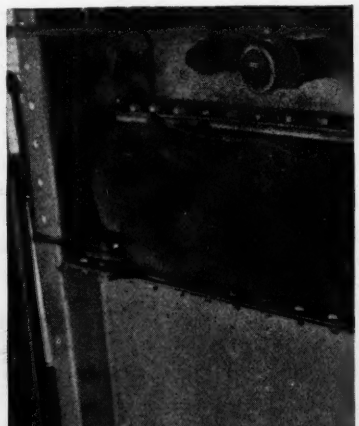




AT THEIR FINGERTIPS—Finding the right drawing or chart or performance record is no difficult task in the engineering department of Weyerhauser Timber Co. at Everett, Washington. The photograph above shows the elaborate filing system that has been developed and placed in service there. The drawings are kept in specially designed frames which slide into racks as shown. Pivoted arms underneath the racks swing out so as to provide a support for the frames when they are withdrawn from the racks for reference. Charts occupy both sides of the frames. Complete performance records are kept at this plant which is the Pulp Division of the Weyerhauser Co. of every piece of important equipment used in the plant and of all commodities used. The frames holding the charts are light in weight and can be removed from or placed in the racks with little effort. A special lighting fixture above provides a high intensity of illumination.

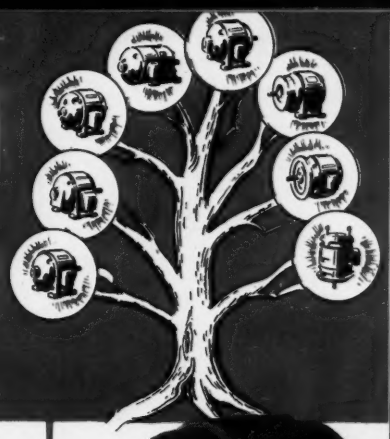


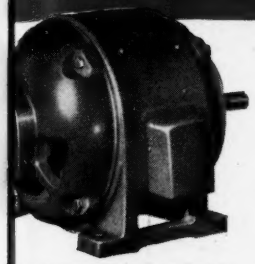
IN CASE C.C. FAILS. At the plant of the Atlantic Gelatin Co., Inc., at Woburn, Mass. Albert Favar, the chief operating engineer, has devised the arrangement shown above so that he can set his induced and forced draft fan dampers in case the automatic combustion control system fails. As shown, he has attached levers to the damper shafts and has calibrated their position for various boiler loads. Thus even if the automatic draft control should become inoperative for one reason or another, the draft dampers can still be set manually at the proper positions for the existing loads.



REMOVABLE INSULATION—Heavy bags filled with 85 per cent magnesia are used on the new Riley boilers in the East Peoria Station of the Central Illinois Light Co. along headers which must be accessible and cannot be covered permanently. These bags are made of asbestos cloth the same as fireproof theatre curtains and filled with fibrous insulating material.

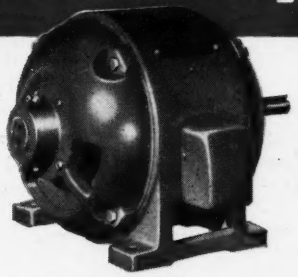
TRI-CLAD* protection is now a *family affair!*





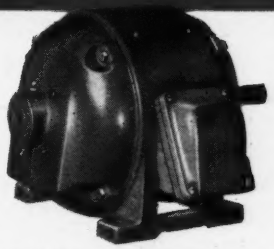
Tri-Clad Sleeve-bearing Polyphase Industrial Motor Is Most Widely Used

A well-protected, open motor for industry's general-purpose needs. Horizontally mounted—for direct-connected and belt drives—it is economical to operate.



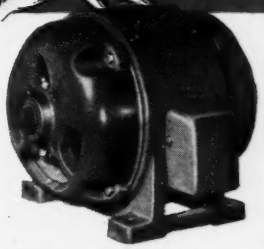
Tri-Clad Ball-Bearing Polyphase Motor

Has additional advantage of being mountable in other than horizontal positions. Will take end thrust—for example, from beveled-gear pinion. Similar to the sleeve-bearing motor and, like it, available in many types.



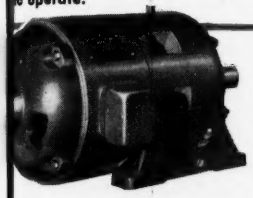
Tri-Clad Splashproof Ball-bearing Polyphase Motor

For use in wet surroundings, such as dairies, paper mills, canning factories, etc. Furnished with cast-iron, waterproof conduit box, deflecting endshields, and moisture-resistant insulation.



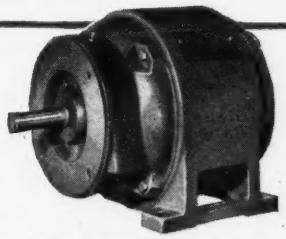
Tri-Clad Capacitor-Motor (in sleeve-bearing or ball-bearing types)

For single-phase operation. Available in types to drive such devices as compressors, pumps, fans, blowers. No radio interference; no brushes to wear; quiet in operation.



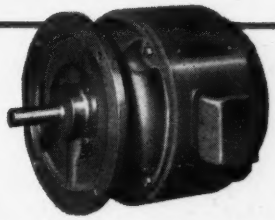
Tri-Clad Gear-Motor

For economical, compact, low-speed direct or pinion drive. Wide range of output speeds available. Open, splashproof, and capacitor-motor construction. Oil- and dust-tight housing reduces maintenance. Easy to mount.



Tri-Clad Ball-bearing Induction Motor, with Face-type End-shield Mounting

For close-coupled attachment to machine tools, compressors, pumps, etc. Motor bolted from driven machine. A few standard mounting dimensions apply to many ratings.



Tri-Clad Round-frame, Ball-bearing Induction Motor with Flange-type End-shield Mounting

For close coupling, for direct bolting to driven machine. Mounting dimensions are standard, but larger than those of motor at left.

Tri-Clad Vertical Motor

For general purpose fan, pump, and machine drives in vertical position. Both polyphase and capacitor-motors available with solid- and hollow-shafts and shielded construction with a variety of bases.

The improvements in Tri-Clad motor design are *fundamental* improvements, not just "sales features" to popularize a new model. That's why they are being extended, month by month, to a whole family of G-E integral-horsepower motors—both general-purpose and special types.

These new members of the Tri-Clad family are the result of basic redesign to meet modern industrial conditions. Each has new performance and convenience features important to its particular field of service. For complete information on the right Tri-Clad motor for *your* application, consult our local office, or write General Electric, Schenectady, N. Y.

BUILT FOR PROTECTION FIRST . . . TO LAST

Today a wider range of your special needs can be filled by the growing Tri-Clad motor family. Every member offers extra strength and longer life because of these 3 "extras"

- ***Extra Protection*** AGAINST PHYSICAL DAMAGE. Cast-iron frame and end-shields.
- ***Extra Protection*** AGAINST ELECTRICAL BREAKDOWN. Stator windings of Formex wire.
- ***Extra Protection*** AGAINST OPERATING WEAR AND TEAR. New sleeve-bearing design.

In addition, you'll find the modifications to meet special requirements are soundly engineered to give you space-saving, time-saving, and money-saving advantages all down the line. Consult your G-E representative for Tri-Clad horsepower ratings now available.

*Reg. U. S. Patent Office.

GENERAL ELECTRIC

GEARS — Friction and Lubrication

By Vernon M. Huff

Temperatures at which lubricants are satisfactory are governed by speed, load, application, room temperature and viscosity. In gears if the lubricant has sufficient body to prevent surface contact, increase in viscosity will only result in increased fluid friction and higher operating temperatures. High temperatures reduce viscosity and film strength, cause oxidation and hasten the oil breakdown*

GEARS are employed where it is desirable to have an absolutely positive velocity ratio between driven and driving power transmission units. In the early use of gearing, beginning with surface friction gearing, it was found, that to transmit any appreciable power and to have positive power transmission without slippage, it was necessary to provide the gear surfaces with grooves or teeth, to bring about a positive ratio in the driven and the driving members. These become what is known as pith surfaces.

Gear Nomenclature

Gear teeth must have the ability to transmit uniform power and speed ratio from one shaft to another without slippage or loss of power in the process. The action of one tooth upon another is considered a rolling motion which minimizes the frictional wear between the revolving teeth of the gear. However it is found impossible to provide a positive rolling action and maintain speed ratio and the practical result is a combination of rolling and sliding motion. Gear teeth are of uniform strength and dimension, and are symmetrical in shape to allow of operation forward or backward. The radius is usually great enough to allow two or more sets of teeth to be in contact at the same time.

Gear dimensions are designed by pitch and circle, or the combination of both. Circle pitch means the distance from a point on one tooth to the same point on the next tooth, measured on the pitch circle. The circular pitch is equal to the circumference of the pitch circle divided by the number of teeth in the gear. The diametral pitch is equal to the number of teeth in the gear divided by the pitch diameter. This is not a dimension but a ratio. Chordal pitch is that distance from one tooth to a similar point on an adjoining tooth measured on the chord of the pitch circle instead of on the circumference. The thickness of a tooth is measured on the pitch line, and tooth space is the width of the space on the pitch line. Backlash is the difference between the tooth space and the thickness of the tooth, and by the term addendum is meant the distance from the pitch circle to the ends of the teeth.

Clearance is the difference between addendum and the dedendum, or the space between the clearance circle and the meshing teeth. Face is that tooth profile laying between the pitch circle and the end of a tooth while flank is that part of the face which lies between the pitch circle and the clearance circle. By the term speed or velocity ratio is meant the ratio of the number of r.p.m. of the driven to the r.p.m. of the driver gear.

Gear teeth are made by two processes, machine cut and molded. From the description it is obvious that molded teeth are very rough and produces a high friction in service. As with other machined surfaces, machine cut teeth contain a microscopic surface of small hills and valleys. These also produce friction between the rolling bodies in contact. The friction produced in meshing gears is primarily rolling friction. However gear teeth do produce some sliding friction in action or motion of the meshing of the teeth.

Figure 1 shows the relative position of gear teeth in mesh, the rolling surfaces contact with a revolving action usually on two or more teeth at once. It is these contact areas that produce wear on the gear teeth. This area and the action varies somewhat with the various types of gears, such as, spur, beveled, helical, hypoid, etc. However in the main, the frictional reaction is similar in all types. Molded teeth are found only on rough and heavy pressure gears. Machine cut gears are used on all high grade precision machines.

Rolling friction is the resistance that a rolling body meets from the surface of the body on which it rolls. Friction between the two bodies is due to the roughness and uneveness of the surfaces, the hills and valleys. In the case of rolling friction, the elevations tend to fit into the depressions as shown in Fig. 2, when the one body rolls along or over the other, the action is somewhat similar to the action of the gear teeth. The action is less than that encountered in sliding friction, and there is therefore less wear.

Friction of dry surfaces is independent of the speed of the motion as well as the area of the surface contact. Lubrication lessens the friction between the rolling surfaces and reduces wear to a minimum. The coating of the surfaces with even a very slight film of lubricant will reduce friction

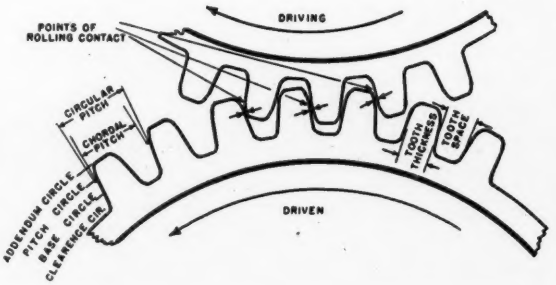
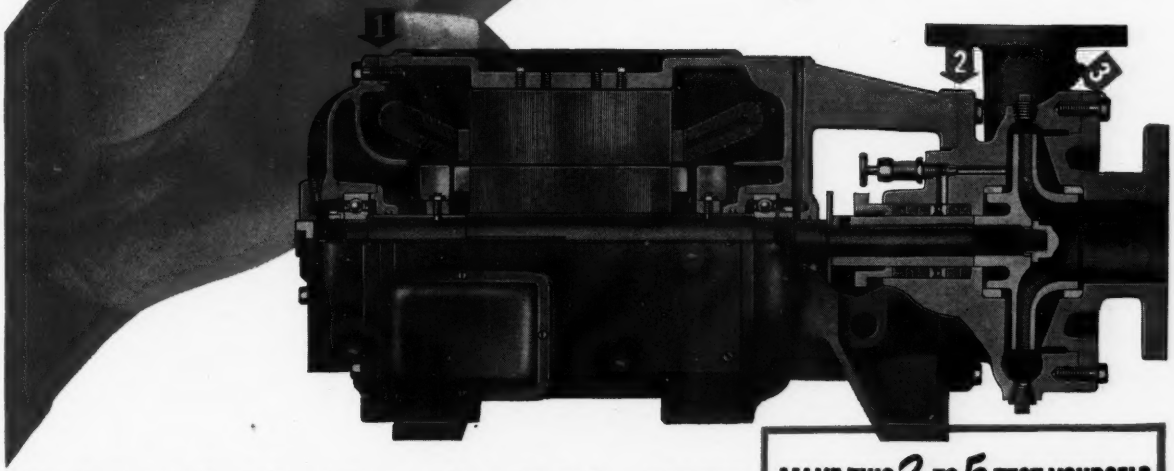


Fig. 1. Sections of typical spur gears showing nomenclature and points of contact

*This is the third of a series of articles on practical lubrication. The first on bearings appeared on page 56 of the April 1941 issue and contained tables of oil properties for different services and service conditions. The second, on page 69 of the June issue, dealt primarily with steam engine, Diesel engine and air compressor cylinder lubrication.

THREE SECTION-FITS

Make Engineering News!



Allis-Chalmers Electrifugal Pump Offers Exclusive "Tri-Fit" Design with One Piece Casting for Motor, Pump and Bearing Housing, Pump Bracket and Feet . . . Cuts Costs Up To 33%!

ANOTHER ENGINEERING SCOOP for Allis-Chalmers! A new, compact pump unit that offers you these outstanding improvements...

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A new motor. . . 100% designed for pump drive and *completely splash-proof* . . . gives far more efficient power.

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Best of all . . . *it cuts your costs up to 33% over conventional pump installations.*

For the money-saving details on this new "One Package" Pump . . . call the engineer in the district office near you. Or write Allis-Chalmers, Milwaukee, Wis. for Bulletin B-6140. A-1443

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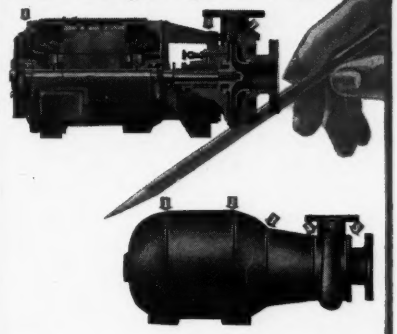

The NEW Allis-Chalmers Electrifugal Pump has only three section-fits compared to five or more for old style pumps! That means more perfect alignment of the shaft . . . less vibration . . . less wear . . . less trouble. Here's a pump that gives you more gallons . . . for less cost!

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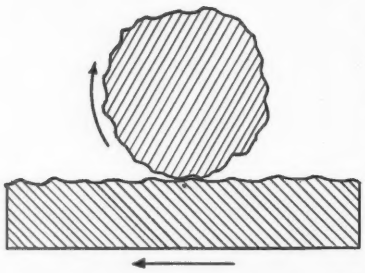


Fig. 2. Rolling friction depends upon the pressure, roughness and chararcter of the surfaces

and wear on lightly loaded gears. With the two surfaces in contact, the capillary action tends to draw the lubricant into the microscopic hills and valleys. With a more adequate supply of oil, the rolling motion between the teeth of the gear acts to carry the lubricant into the contact area, resulting in a greater part of the pressure being absorbed by the lubricant, and leaving little or no metallic contact between the teeth. In meshing gears the contact between the teeth is restricted to a very narrow space, which makes the unit pressure very intense in this area.

Lubricants

Two convex surfaces are in contact in the gears mesh, and as these surfaces roll one upon the other, the lubricant is pressed in an abrupt manner which tends to squeeze it out of the contact area. The selection of a proper lubricant for gears, as in the case of bearings or cylinders, depends on the type of gear and the operating conditions. Gears may be open and exposed, or they may be enclosed in a tight fit case. They may be high speed or very slow, heavy or medium pressure.

In gear reduction sets, the gears are usually high speed, frequently with high pressure also. Methods of application varies in the several types, high speed reduction sets being bath oiled, operating in a continuous bath of oil. In steel mills, paper mills, coal mines, etc., open gears are prevalent. The requirements for this type of gears is dependent on the operating conditions and the pressures. They require a lubricant that will remain in liquid form, one that resists gumming to prevent clogging in the gears.

Lubricants for open gears require an extreme characteristic of adhesiveness and film strength. They must be capable of resisting heavy pressures and high temperatures. They should be fluid for ease of application, or contain an inhibitor in the form of a solvent for retaining fluidity until after application. The duration of contact in the large open gears is relatively long and the lubricant must retain film strength to resist pressure and rupture during the contact period.

Worm gears constitute a severe condition both from pressure and the sliding action of the thread on the contacting teeth. This type of gear tends to develop high temperatures and requires a lubricant suitable to this condition. As with the plain open gear, the worm gear must retain an oil film between the moving surfaces. Worm gears are usually splash lubricated, especially in slow or moderate speeds. A medium grade of steam cylinder oil is found to give satisfactory service in this type of gear.

Reduction Gearing

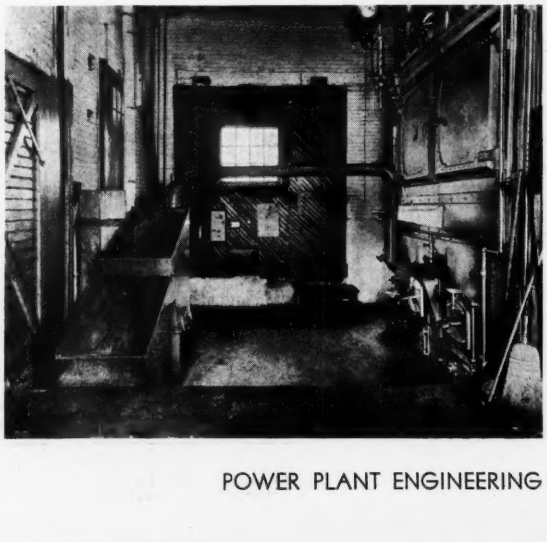
Gear reduction sets are employed to reduce speeds lower than the driving unit. They are operated at high speeds and heavy loads and require extreme smooth performance. Gear reduction sets are designed for splash lubrication on the gears, and in the newer installations, the systems have a spray arrangement for showering oil into the gear teeth at the meshing point. These systems also have cooling facilities and only one oil is used for gears and bearings. The teeth in high speed enclosed gear reduction sets are very accurately cut, which together with more efficient lubrication facilities, assures smooth operation. The viscosity or body of the lubricating oil is selected according to the gear duty. Usually a high grade steam cylinder oil is found to give excellent service and long life.

Bevel gears are used to transmit power to single pinion drives. They are heavy duty in service, usually operating under severe pressure and thrust. They may be open or enclosed gears. They require a heavy bodied oil with an extreme tacky characteristic to resist the squeezing action of the pressure exerted on the teeth.

With metallic contact, high speeds lead to high friction and excessive wear. When proper lubricants are used, and when mechanical conditions are correct, high speeds constitute a favorable factor in forming and maintaining an adequate oil film. This factor has made possible the use of high speeds in modern heavy duty machinery. It also permits lighter bodied oils necessary to modern lubricating systems. The opposite is the practice where speeds are slow. Then the requirement is for extreme film strength and adhesiveness found only in heavy bodied oils.

Temperatures at which lubricating oils will perform satisfactorily are governed by speeds, loads and application, as well as room temperature. It is dependent also on the viscosity of the oil. In a gear reduction set, so long as the lubricant has sufficient body to prevent surface contact, any increase in its viscosity will only result in increased fluid friction and higher operating temperatures. High temperatures reduce viscosity and film strength. They cause oxidation and hasten the breakdown of oil in service.

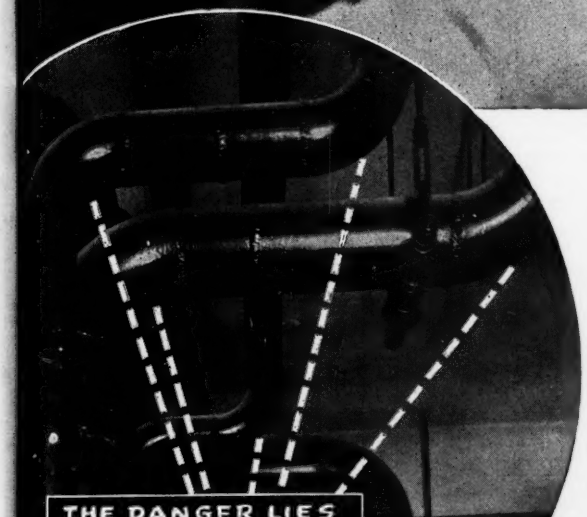
DOES THE WORK OF TWO—AND LIKES IT



PUTTING the old coal scoop in the corner paid good dividends to Traylor Eng. & Mfg. Co., at Allentown, Pa. Since this 214 hp. boiler was equipped with an Iron Fireman pneumatic spreader stoker its 185 hp. hand fired companion has been on standby; boiler room labor reduced to filling the stoker hopper; and coal costing $1.04 per t. less is used.

On a recent test the boiler showed an efficiency of 73.7 per cent and pulled a peak load of 443 b.hp.

IN YOUR PIPING SYSTEMS, TOO . . .



THE DANGER LIES AT THE **TURNS**

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Flue Gas Analysis Made Easy

Easily constructed charts facilitate calculation of flue gas analysis from orsat readings for a given oil or gas

By Chas. Hubbard

IT IS OFTEN advisable to have a chart or a table showing the flue-gas analysis to be expected from a given fuel oil. Such tables and charts will serve to check the actual analysis obtained by experiment. If the variation from the expected result is considerable, then the analysis should be examined critically and the Orsat checked for strength of reagents and leaks. Also these charts can be used to obtain the probable percentages of CO_2, O_2, N_2 for any assumed excess air ratio, when it is necessary to have these data for use in the formula to obtain the heat loss in the dry flue gas.

To make the calculations necessary to obtain values for the chart, the carbon and hydrogen content of the fuel oil must be known or approximated. The carbon and hydrogen content varies considerably,

Table I. Table showing calculated values of the percentage of dry gases as a function of the excess air ratio. These data are for a fuel oil of 86 per cent carbon and 12 per cent hydrogen (2 per cent undetermined) with zero CO_2 assumed

Excess Air Ratio	Excess Air Per Cent	Carbon Dioxide Per Cent	Oxygen Per Cent	Nitrogen Per Cent
1.0	0.00	15.84	....	84.16
1.1	0.10	14.30	2.03	83.67
1.2	0.20	13.04	3.70	83.26
1.3	0.30	11.99	5.12	82.89
1.4	0.40	11.09	6.29	82.62
1.5	0.50	10.32	7.32	82.36
1.6	0.60	9.65	8.21	82.14
1.7	0.70	9.06	9.00	81.94
1.8	0.80	8.54	9.69	81.77
1.9	0.90	8.07	10.31	81.62
2.0	1.00	7.66	10.86	81.48

Table II. Comparison of results from actual test records, a small 5 in. chart and a large 20 in. chart. The fuel oil in this case was in per cent: C, 85.90; H, 11.60; S, 0.65; N, 0.24; undetermined 1.61. The discrepancy between this analysis and the oil for which the chart was made caused little difference

Flue Gas Analy.	Test Record	Small 5 in. Chart	Large 20 in. Chart
CO_2	13.03	13.00	13.00
CO	0.09	....	....
O_2	3.32	3.75	3.60
N_2	83.56	83.20	83.38
	100.00	99.95	99.98
Excess Air Ratio	1.20	1.21	1.195

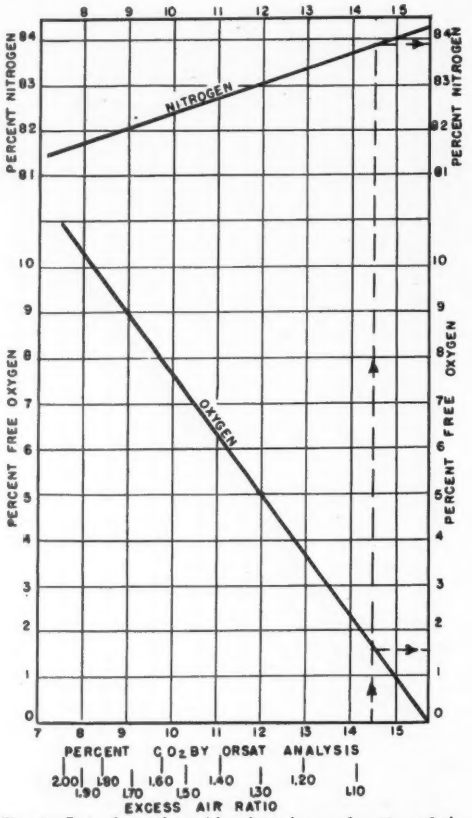

Fig. 1. Data from the table plotted as a function of the CO_2. This chart is for fuel oil with 86 per cent C, 12 per cent H and no CO_2 in the flue gas. The example illustrated starts from the bottom scale for 14.5 per cent CO_2 as read from an orsat

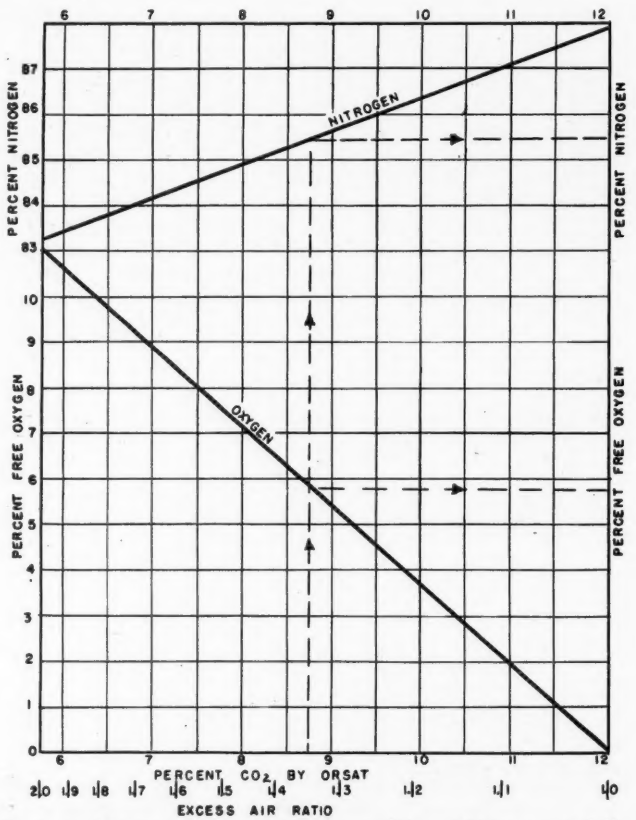

Fig. 2. A chart for natural gas, 78.2 per cent CH_4 and 21.8 per cent C_2H_6. The example illustrated by the dotted line starts from a CO_2 reading of 8.75 per cent. Values of free oxygen, nitrogen and excess air are obtained as indicated directly from the chart. The excess air—CO_2 scale may be plotted as a separate curve if desired to facilitate conversion

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one authority gives carbon content varying from 83.7 to 90.6 and hydrogen from 9 to 14.5. A fair average appears to be 86 per cent carbon and 12 per cent hydrogen and these values were used in preparing the table. The oxygen, nitrogen, sulphur, and B.S. that make up 2 per cent were disregarded because in general the exact ultimate analysis of each batch of fuel oil received will vary from the preceding batch. The charts should not be used unless it is reasonably certain that the fuel oil does not vary greatly from 86 per cent carbon and 12 per cent hydrogen.

To calculate values for the curves formulas as follows were used. The fuel oil is assumed to have 86 per cent carbon, 12 per cent hydrogen and 2 per cent inert.

a. Per cent $CO_2 =$

$$\frac{100 \times C}{C + (4.75 \times X - 1)(C + 3 \times H)}$$

b. Per cent $O_2 =$

$$\frac{100 (X - 1)(C + 3 \times H)}{C + (4.75 \times X - 1)(C + 3 \times H)}$$

c. Per cent $N_2 = 100 -$ per cent $CO_2 -$ per cent $O_2 =$

$$\frac{100 (3.75 \times X)(C + 3 \times H)}{C + (4.75 \times X - 1)(C + 3 \times H)}$$

Where

% CO_2 = Per cent by volume of carbon dioxide in sample

% O_2 = Per cent volume of oxygen in sample

% N_2 = Per cent by volume of nitrogen in sample

C = Per cent of carbon by weight in the fuel oil (Sulphur is used in terms of C, in the ratio of 8 to 3, thus total $C = C + \frac{3}{8} S$

H = Per cent of hydrogen by weight in the fuel oil

X = Excess air ratio =

$$\frac{\text{Volume of air supplied in actual combustion}}{\text{Volume of air calculated for theoretical reaction}}$$

The derivation of these formulas can be found in text books, one such book is "Mechanical Engineering Laboratory Methods" by Smallwood, pages 168-169, 1914 edition. D. Van Nostrand, N. Y. The constants 4.75 and 3.75 are even approximations of the more exact values 4.78 and 3.78.

To show use of formulas, assume that $X = 2.0$ and solve for $CO_2 - O_2 - N_2$

Per cent CO_2

$$= \frac{100 \times 86}{86 + (4.75 \times 2 - 1)(86 + 3 \times 12)}$$

$$= \frac{8600}{1123} = 7.66$$

Per cent O_2

$$= \frac{100 (2 - 1)(86 + 3 \times 12)}{86 + (4.75 \times 2 - 1)(86 + 3 \times 12)}$$

$$= \frac{12{,}200}{1123} = 10.86$$

Per cent N_2

$$= \frac{100 (3.75 \times 2)(86 + 3 \times 12)}{86 + (4.75 \times 2 - 1)(86 + 3 \times 12)}$$

$$= \frac{91{,}500}{1123} = 81.48$$

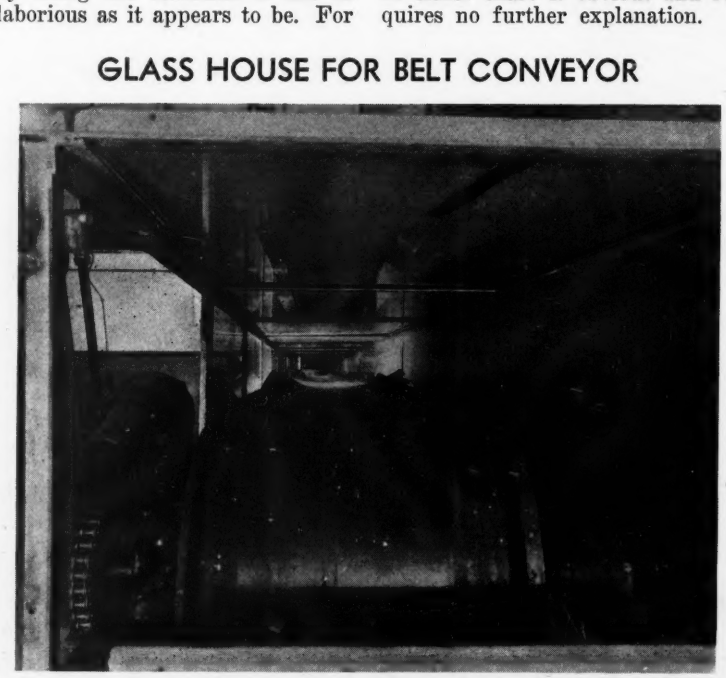
To prepare a table assume values of the excess air ratio in steps over the desired range and solve in the foregoing. For instance ten values of X such as 1 — 1.1 — 1.2 — 1.3 ——2, will give sufficient points for most purposes or for plotting a smooth curve. From the curve the values of O_2, N_2 and X can be obtained for any selected value of CO_2.

To obtain values for the chart by using the formulas is not as laborious as it appears to be. For each assumed value of X, the denominator in all three equations is the same. $(C + 3 \times H)$ is common to all numerators. In the numerator of the N_2 formula the term $100 \times 3.75 \times (C + 3H)$ is constant for any assigned set of C and H values.

By arranging the constants, a man and a boy with a slide rule could prepare a chart in less than an hour. The table shows values from an analysis taken here, and values for the corresponding CO_2 taken from a chart. There is a variation, but it is not great, even checking by formulas and accounting for CO content, the variation in the O_2 values is only 2 per cent.

A chart arranged so that the points fall on a straight line is more convenient to use and is much easier to construct. In fact only two points on each curve need be calculated, although it is well to include a third as a check on the calculation. Inasmuch as the excess air bears a fixed relation to the CO_2 a chart of this kind with straight lines can be made using the CO_2 readings as a uniform scale as in Fig. 1. Note the difference between the excess air ratio and the per cent excess air in the table. Figure 2 is similar to Fig. 1, but is drawn for natural gas instead of fuel oil. The use and application of either chart is obvious and requires no further explanation.

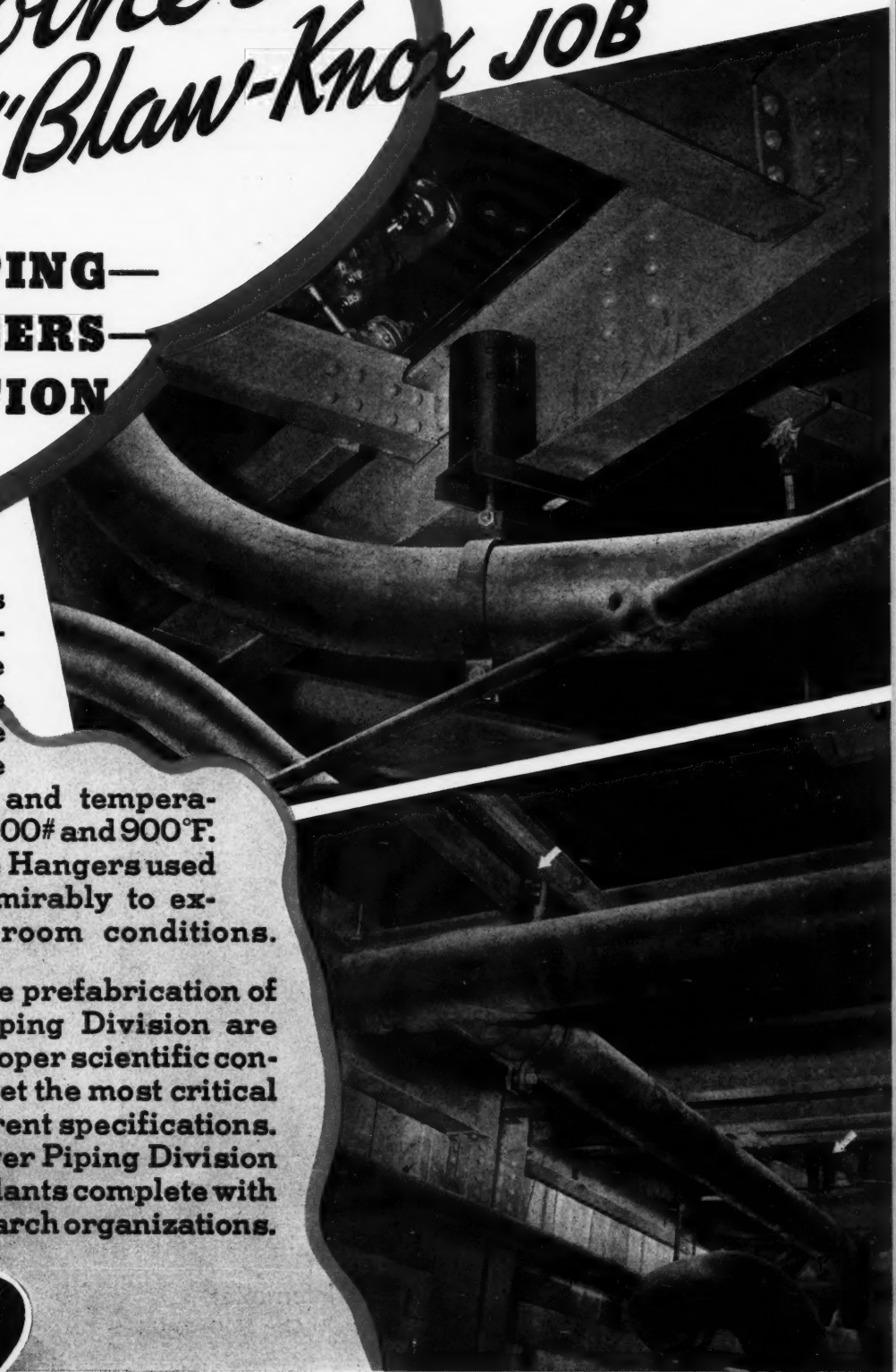
GLASS HOUSE FOR BELT CONVEYOR



When a conveyor belt as large as this one operates in a completely enclosed glass case there is an industrial reason. The unusual installation is used by an eastern rayon manufacturer to convey broken pulp. The glass case was devised to prevent loss of moisture in the pulp during an important step in the manufacturing process

Another "ALL OUT" Blaw-Knox JOB

PIPING— HANGERS— INSTALLATION



The photographs show another Blaw-Knox high pressure —high temperature installation complete with hangers; the operating pressure and temperature is respectively 900# and 900°F. The Functional Type Hangers used lend themselves admirably to extremely low head room conditions.

All processes in the prefabrication of piping by Power Piping Division are accompanied with proper scientific control necessary to meet the most critical interpretation of current specifications. The facilities of Power Piping Division include six modern plants complete with engineering and research organizations.

A copy of "FLEX-ANAL CHARTS" To any engineer asking for it on his Business Letterhead.

Send for Bulletin entitled POWER PIPING FUNCTIONAL HANGERS AND VIBRATION ELIMINATORS

BLAW-KNOX COMPANY

POWER PIPING DIVISION

1525 Pennsylvania Ave., Pittsburgh, Pa.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

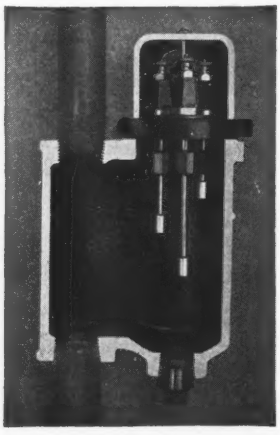
Flexible Coupling

PILOTED couplings for floating shafts, as on paper and steel mills, pumps and fans is offered by The Falk Corp., Milwaukee, Wisc. Resiliency and shock cushioning with low-angle universal joint action are designed to eliminate outboard or auxiliary bearings, reduce space requirements and permit flexibility

in location of units. Of the two hubs, one carries an integral flange to which the cover is secured; the other is a tempered steel cylindrical grid member. This Type P coupling is made as single piloted for a long shaft extension, double piloted horizontal using two couplings for long shafts, double piloted vertical using two couplings for vertical shafts of considerable distance between driving and driven units.

Multiple Boiler Water Control

THIS NEW system which maintains safe and proper water levels in two or more boilers with one boiler feed pump, has been announced by the Johnson Corporation, Three Rivers, Mich. Each



boiler water level is controlled separately, and water added independently of other boilers, as the need arises. The system is electrically controlled and completely automatic in operation. Two stationary electrodes, of different lengths, are mounted in a small holder on each boiler, which can be mounted on the water glass column or connected to other suitable openings in the boiler.

When water level in any boiler falls below the longer electrode, an electric circuit is disturbed which, through a relay, starts the boiler feed pump, at the same time opening a motor-operated valve to divert pump discharge into the boiler requiring water. When water level reaches the desired point the pump stops. When necessary, all boilers can be fed simultaneously.

This control is suitable for pressures up to 150 p.s.i., for boilers up to 250 hp., with any type of steam or motor-driven boiler feed pump; also can be arranged with a duplicate stand by or emergency, pumping unit. An auxiliary condensation receiver is installed behind the pump, equipped with another Johnson water level control that automatically adds make-up water to the system as needed.

Power Wrench

STURDY, air-operated impact wrench with aluminum alloy housing for light weight, size 508, is announced by Ingersoll-Rand Co., Phillipsburg, N. J. Oper-

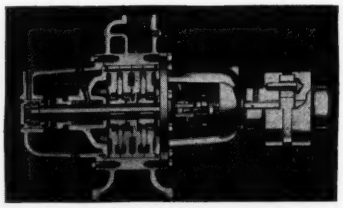
ation is by one hand, with pistol grip and trigger throttle. Turn of a lever reverses the motion. Five sizes cover a range for nuts ¼ to 1¼.

Circuit Interrupter

FOR USE in Class II, Group G locations where atmospheres contain grain dust, a new non-automatic circuit interrupter is announced by Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. The interrupter is furnished with NEMA Type 9 enclosures that exclude dust from hot or arcing parts and permit operation under a dust blanket without a dangerous rise in temperature. Enclosures are made of cast iron finished in aluminum and have a machined fit between box and cover. Units are rated from 50 to 600 amp. in 4 frame sizes for use on a.c. circuits up to 600 v. and d.c. circuits up to 250 v. The interrupting capacity is 500 to 10,000 amp. depending on frame size.

Westco Turbine Pumps

SINGLE and two stage Westco Turbine Pumps incorporating an improved type of renewable liner have been developed by Micro-Westco Inc., Bettendorf, Iowa, and recently placed on the market. This exclusive feature mini-

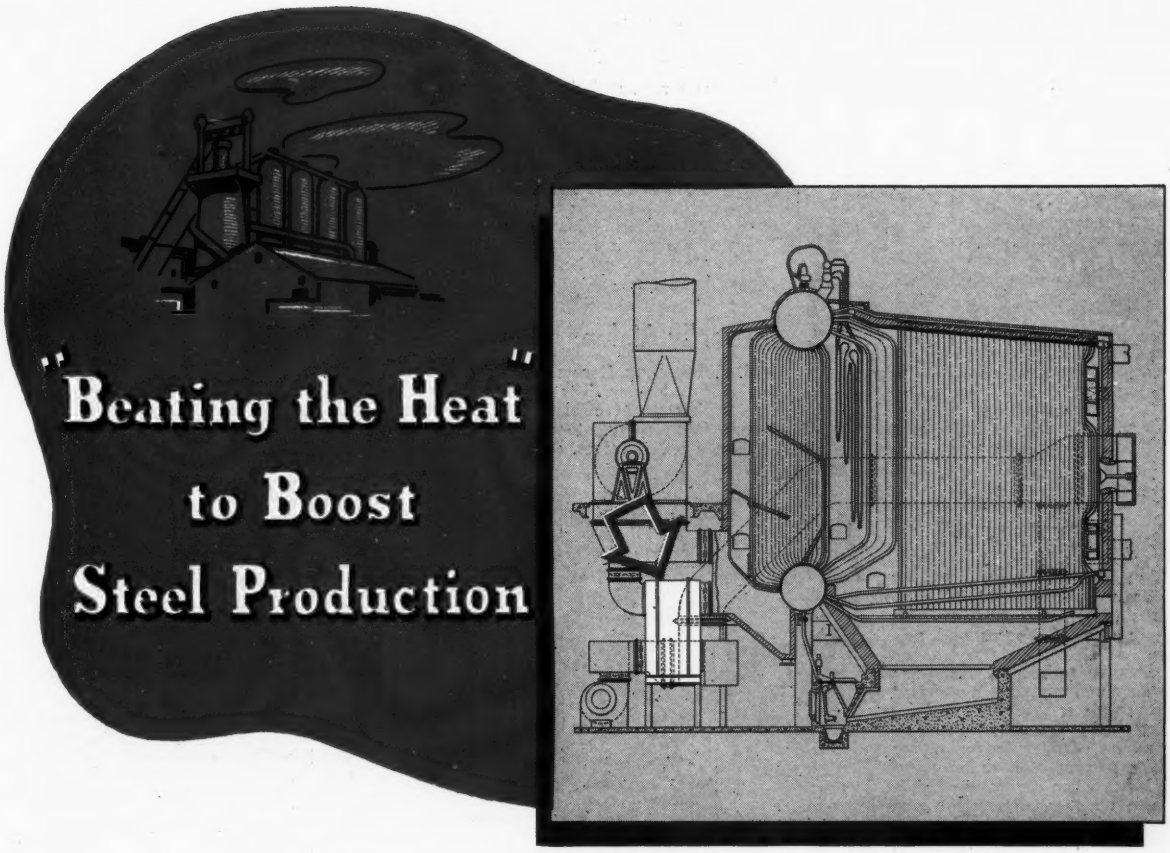


mizes shut-down losses and production delays, for the liners, forming the liquid channel within the unit, can be easily renewed (along with the impeller), providing complete stand-by service at about ¼ the usual cost of a duplicate unit.

This separate liner design also permits the pump capacity and range to be altered, within reasonable limits, in the field. This alteration is accomplished by replacing the liners with a different set and slipping a new, matching impeller into position, without disturbing pipe connections.

Other constructional features include double ball bearing construction, for maximum operating ease and longer life; a top discharge, preventing vapor lock; a stainless steel shaft and "free-floating" impeller, to eliminate seizing caused by extreme temperature variations; extra deep stuffing boxes that reduce the need for frequent repacking; and balanced bearing arms which minimize shaft misalignment.

Designed especially for high-head low-capacity work, these pumps are engineered to meet the many industrial applications requiring high pressure performance. For example, single and two stage pumps, with 5-in. impellers, will develop pressure up to 150 and 300 lb. per sq. in. respectively at 1750 r.p.m. This wide range operation makes these pumps suited for brine circulation, steam service, liquid transfer, filtration, air conditioning, beverage and liquid food pumping, booster service, spray equipment, industrial washing machines, water supply systems, laundry and dry cleaning work.



"Beating the Heat" to Boost Steel Production

Three of these flexible steam generating units are helping to meet peak demands for power at a plant of one of the nation's most efficiency-minded steel producers. They are designed to burn blast furnace gas, oil, or gas and oil in combination, and are easily adaptable to pulverized coal. Whatever the fuel, high heat recovery and efficient combustion are aided by Ljungstrom Air Preheaters. When a boiler is operating on blast furnace gas at its rated capacity of 75,000 lb. steam per hr., gases enter the preheater at 600° F., leave at 473°, heating combustion air to 500° F.

• • • • •

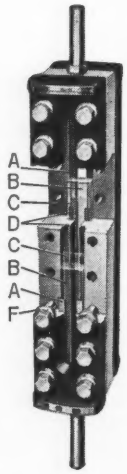
To meet today's extraordinary demands on the steel industry, power generation must keep pace with production. Boiler plants are being called on for peak production and continuous service on the line. Wherever Ljungstrom Air Preheaters are in operation, you can count on maximum heat recovery 'round the clock, with virtually no possibility of a serious service interruption at the preheater. You save *more heat* in *less space*. Cleaning and servicing are quickly accomplished at times of scheduled outage, and can be postponed in an emergency without serious consequences.

Once you check the economics of the *continuous counterflow principle* against other types of preheaters you'll see why the Ljungstrom leads the field on high efficiency power plants...why it meets peak load conditions or variable load conditions, using any fuel, with an extra measure of value . . . why it's your best bet for "beating the heat", by getting the most out of it. *Just write us for the figures.*

THE AIR PREHEATER CORPORATION

Executive Offices: 60 East 42nd St., New York, N. Y. **Plant: Wellsville, New York**

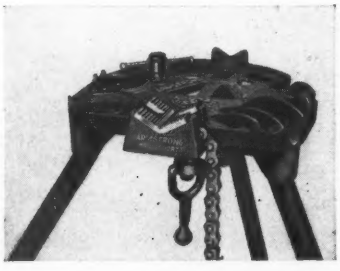
Water Level Gage for High Pressure



THE Yarnall-Waring Co., Chestnut Hill, Philadelphia, announces its improved Pressure-sealed Flat-glass Insert for boiler water level gages, built for pressures up to 1500 p.s.i. Pressure-sealed gaskets are used on inside faces of glasses and special spring-loaded cap screws hold down front and back cover plates. Cushion gaskets (A) are used on outer faces of glasses (B). Thin sheets of india ruby mica (C) protect inner surfaces of the flat glasses from etching action of steam and water. Pressure-sealed, molded Vulcabeston gaskets (D) fit into body recesses on pressure side of glasses and provide tight joints between body and glasses without excessive tightening of covers. Special shouldered cap screws are used to fasten cover plates to body. Spring cones (F) attached to each cap screw limit the amount of pressure on glasses and gaskets to prevent harmful compression on glasses when covers are tightened down, take up expansion and contraction and allow for slight variations in thickness of covers, glasses and gaskets.

Integral Vise and Stand

UNUSUAL strength is built into the new heavy-duty Vistand with integral chain vise recently announced by the Armstrong Mfg. Co., Bridgeport, Conn. At the same time, it is light enough to be easily portable and is well balanced, being designed to prevent tipping or tilting. It has spreads of 50 in. in front and 43 in. from front to rear leg. The platform measures 14 in. in both width



and depth and has notches and slots for tools around the rim. It is also equipped with three benders placed directly over the right front leg to guard against tipping during the bending operation. One of these benders is for ¾-in. pipe and the others are reverse benders for ½-in. and ¾-in. pipe.

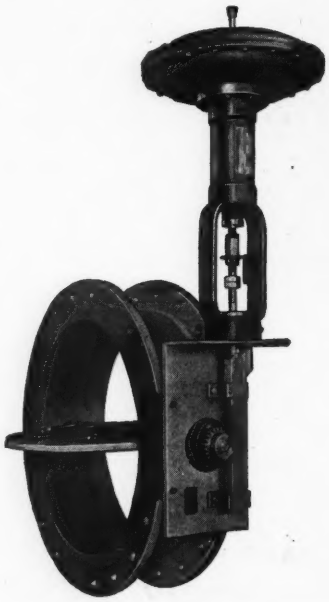
Cast into the platform is a "dope" pot which is round and big enough to hold a 1-lb. can of thread dope. Three equidistant lugs, cast on the rim of the oil can recess, prevent the can from joggling or slipping off without adding the extra weight of a deeper rim.

Another feature is an adjustable ceiling brace screw, and the unit's feet are punched for attaching to the floor, or Armstrong-Bridgeport's rubber shoes, which prevent scratching or skidding on polished floors, may be used.

The teeth in the jaw have hard, long-wearing surfaces, are accurately spaced to hold each size of pipe and each tooth is cut to prevent it from filling up with scale. The jaw is heat-treated by a patented process.

Butterfly Valve

R-S PRODUCTS Corporation of Philadelphia has developed its Butterfly Valve to a high state of efficiency, said to be accurately machined, to close as tightly as double seated valves.



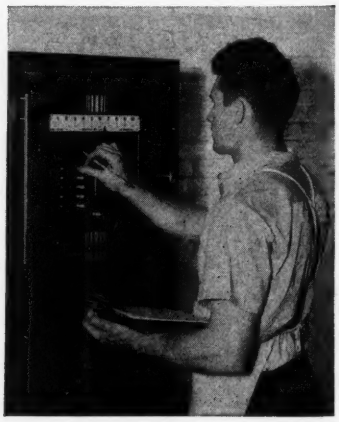
The line includes manually-operated valves, also automatic operation, under high or low pressures and temperatures, in sizes from 2 to 72 in. Extended stuffing boxes and shafts, ball bearings and rotary seals may be furnished as well as special linings. Valves are operated automatically by floats, electric motors, solenoids, steam, compressed air, hydraulic or remote control systems.

2300 Volt Starters

GENERAL ELECTRIC Co. announces a line of 2300-v., 60-cycle starters for protection against shorts and overloads in industrial plants. With oil-immersed contactor having self-cleaning copper tips, wide metal bearings and copper-braided shunts, protection against shorts is by use of EJ-2 fuses to limit current in less than ¼ cycle and open in less than ½ cycle. Overload protection is by isothermic relays and on under-voltage the line contactor opens and requires push button operation to restart the motor Four types are offered, for full-voltage starting, for reduced-voltage starting, for reversing of squirrel-cage motors and for synchronous motors.

Automatic Temperature Indicator

WHERE a large number of thermocouple temperature readings are to be taken, the automatic indicator does the job in minimum time and requires minimum skill on the part of the operator. It is made by Leeds & Northrup Co., Philadelphia, Pa.



As many as 50 couples can be used with one instrument. All are individually connected to toggle-switches on the indicator front. To read a couple's temperature, the operator simply throws its switch, and a pointer moves automatically to the correct scale position. No dials to turn or galvanometer to watch . . . the instrument automatically performs these operations, leaving the operator's hand free to make notations.

Paving Breaker

THIS 60-lb. class "cushioned-air" paving breaker, known as the CC-60, for hard clay, shale, brick, concrete, or other jobs where it is not feasible to use a heavier tool, is made by Ingersoll-Rand Co., Phillipsburg, N. J. It is also fitted for maintenance jobs such as wall openings and foundation work. An air cushion absorbs the blow of the piston when the steel is not in contact with the work, reducing fatigue for the operators and breakage of parts.

Dimensions are: net weight, 63 lb.; length overall, 27 in.; size of steel, 1⅛ in.

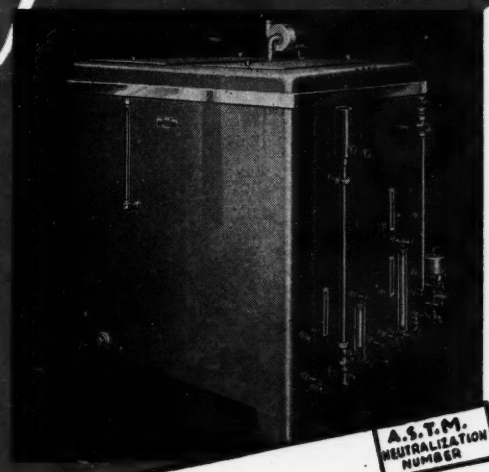
Spring-balanced hinged section for hinged portable elevators is announced by Lewis-Shepard Co., Watertown, Mass. for general use in industry. Compression springs balance the weight of the upper frame, enabling one man to raise or lower it quickly.

BOWSER ESTABLISHED 1885

The MAKER OF THE MOST EXTENSIVELY USED TURBINE OIL SYSTEMS ....

Presents A NEW WORD IN TURBINE OPERATION

OIL CONDITIONING



DATE		A.S.T.M. NEUTRALIZATION NUMBER
APRIL "40"	SYSTEM PUT IN OPERATION	.056
AUG. "41"	SAME OIL AFTER 16 MONTHS CONTINUOUS SERVICE	.014

Power! Speed! More Power! That's what power men hear on every hand as a result of today's accelerated business tempo. Turbo Compressors, blowers and other equipment have to run faster and longer. Turbo-generators are bigger . . . operate at much higher speeds and temperatures . . . have to run unfailingly and continuously for prolonged periods. Lubrication has to be dependable . . . sludge can't be allowed to accumulate to foul oil passages and governors . . . acid cannot be permitted to cause costly bearing wear or shut-downs. To help power men, Bowser developed something entirely NEW and different—the Oil Conditioner—and now offers it, fully field-tested and proved, to make turbine operation easier, more dependable, and more economical.

While it's on your mind—write for more complete information, NOW!

FOR OILS REQUIRING ACID CORRECTION

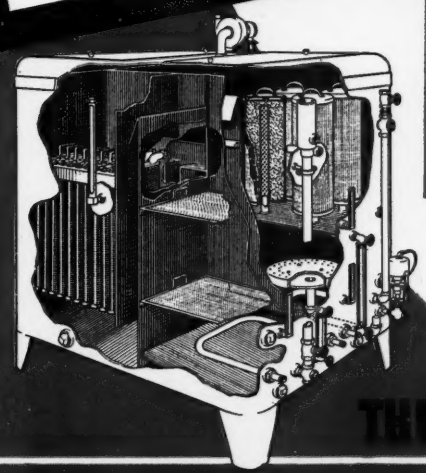
TO PREVENT BUILD-UP OF ACID IN NEW OIL

CUTS LUBRICATION OIL COSTS

S. F. BOWSER & COMPANY, Inc.
1362 Creighton Ave.
FORT WAYNE, INDIANA

PERFORMANCE FACTS PROVE ITS EFFICIENCY

A battery of turbo-compressors. Rapid build-up of acid . . . Oil discarded every 90 days—often in 45 or 60 . . . High maintenance, frequent bearing failure. Then a Bowser Oil Conditioner was installed. Acid brought down. After sixteen months acid content still low (half that of new oil). No bearing failures since.



★ NO AERATION
★ NO TURBULENCE
★ NO FOAMING

THE BOWSER OIL CONDITIONER

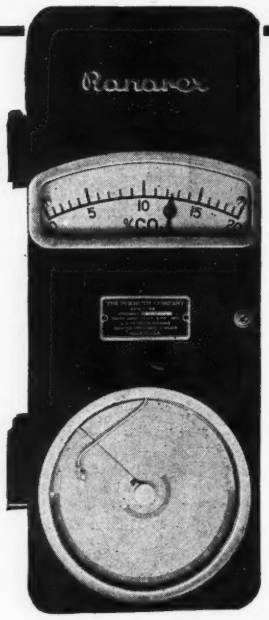
EFFICIENT FILTRATION PLUS
OIL CONDITIONING

Defense production demands

LESS FUEL WASTE "UP-THE-STACK"

Guard combustion efficiency with the mechanical

CO_2 INDICATOR AND RECORDER



Ranarex*

This amazing instrument increases efficiency and cuts fuel costs sharply—users report savings as high as 20%! FAST—gives readings within 30 seconds. ACCURATE—within 3/10 of 1% CO_2. TOUGH—no chemicals or fragile parts—Ranarex can keep pace with today's strained production tempo! Write for free booklet: The Permutit Company, Dept. A1, 330 West 42nd Street, New York, N. Y. *Trademark Reg. U. S. Pat. Off.

product of— **PERMUTIT**

Degassing Condenser

A COMPACT condenser designed to remove carbon dioxide, oxygen, ammonia and hydrogen from samples of steam or condensate has been developed, and is distributed exclusively by W. H. and L. D. Betz of Philadelphia, Pa. This condenser finds application in the removal of non-condensible gases from continuous sampling of steam or condensate where the presence of minute amounts of these gases would introduce serious errors in conductivity determinations of dissolved solids. It will deliver samples containing no more than 0.02 p.p.m. ammonia and 0.02 p.p.m. carbon dioxide, while oxygen and hydrogen are virtually eliminated.

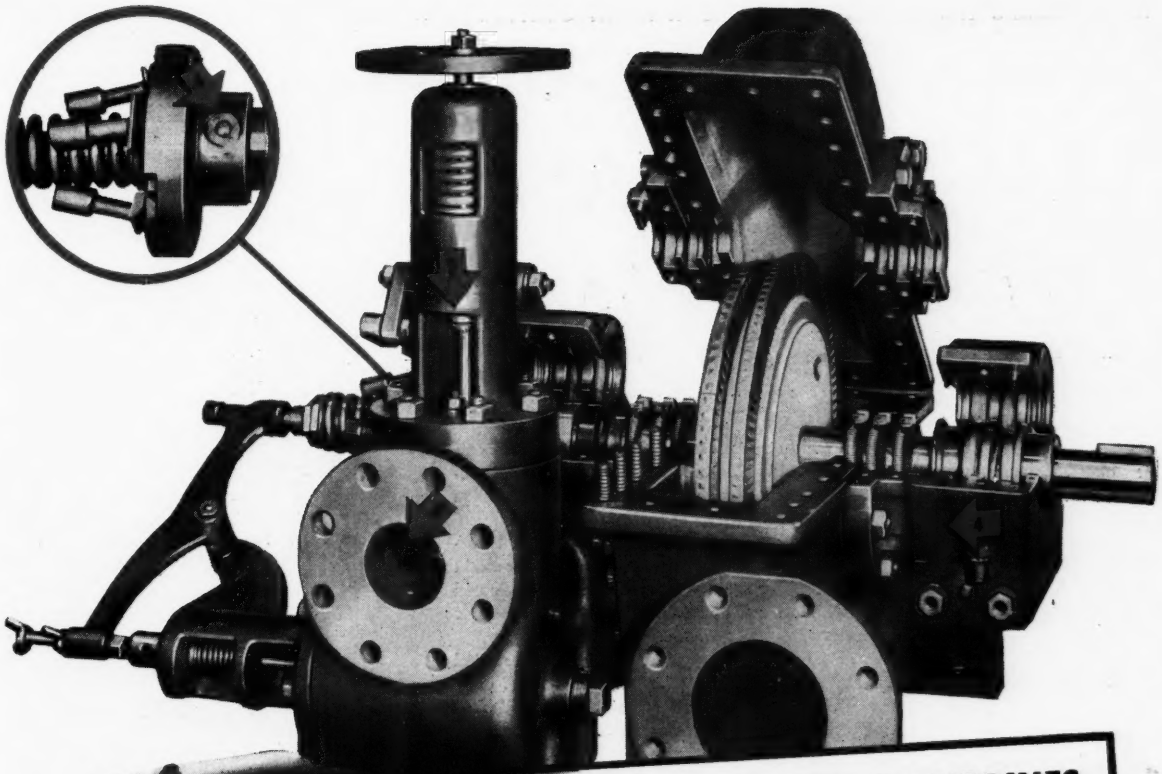
High-Temperature Packing

ASBESTOS packing for elevated temperatures has been added to the Palmetto line of packing by Greene, Tweed & Co. Known as Palmetto Cab Cock Packing, this is braided from long-fibre Canadian asbestos yarn, each strand individually coated with dry graphite to retard fusion of asbestos and to provide anti-friction wearing surface. It contains no liquid lubricant which might be boiled away. It is intended for pumps and valves handling high-temperature steam, oils, and gases; also for expansion joints, furnace door grooves, locomotive cab cocks, and many applications in petroleum refineries.

To visualize how "Baerite" functions in the treatment of industrial and commercial water supplies of all kinds, Water Treatment Co. of America, Pittsburgh, Pa., has devised a "Desk-Top Test" which doesn't take any time or effort. You simply set it on your desk and watch the rust or scale disintegrated.

The Water Treatment Co. of America, originators of the "Desk-Top Test", have developed the "Baerite" Water Treatment for use wherever rust, scale, corrosion, foaming, priming and other water difficulties occur.

Proportional Controller of C. J. Tagliabue Mfg. Co., Brooklyn, N. Y., has now a new control, with only control instrument and valve mechanism, eliminating the relay detector. With temperature low, as in starting, valve is wide open; as temperature rises to the throttling zone, the valve closes a relay, which prevents overshooting when temperature nears the balance point between heat input and output. Throttling zone is adjustable according to lag characteristics of the application. Control of the Celectray is held within a few degrees without reset, but types with manual or automatic reset are available.



4 Reasons

WHY TYPE D TURBINES GIVE YOU MORE FOR YOUR MONEY

THROUGH-BOLT GOVERNOR

The overspeed governor is a through-bolt, spring-loaded, unbalanced weight mounted in the shaft. If for any reason the speed of the turbine increases to the trip speed, centrifugal force causes the weight to move outward and strike the trip device. After tripping, the overspeed mechanism can be reset at the turbine and above operating speed without shutting off the main steam supply.

COMBINED TRIP & THROTTLE VALVE

The combined trip and throttle valve—a standard feature of the improved Type D—admits steam to the turbine and assures protection against overspeed. This valve is spring loaded and, when tripped by the overspeed governor, is closed instantly against all steam flow by both spring force and steam pressure. The chrome-iron alloy valve trim resists corrosion and erosion.

ACCESSIBLE STEAM STRAINER

Monel metal steam strainer is ahead of both the trip and governor valves to prevent foreign material from entering any part of the turbine. Full steam flow with no pressure drop is assured by designing the strainer with 200 per cent more open area than the inlet. Strainer can be easily removed and cleaned without breaking the station piping.

IMPROVED BEARING COOLING

When steam conditions require, a large volume of cooling water can be circulated around the oil reservoir through a cored chamber cast in the bearing bracket. Only the Type D design has an insulating water wall between the steam chest and oil reservoir. The ample depth of the reservoir assures clean lubrication at all times.

MULTI-WEIGHT SPEED GOVERNOR

DYNAMICALLY BALANCED ROTOR

BALANCED PRESSURE GOVERNOR VALVE

DETACHABLE PACKING BOXES

CARBON PACKING GLANDS

CHROME-ALLOY BUCKETS

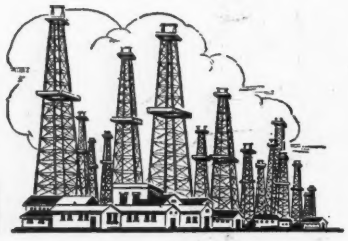
STURDY CONSTRUCTION

GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

GENERAL ELECTRIC

★ THERE'S A BELMONT PACKING FOR EVERY SERVICE ★

FOR OIL



NOW, when every production minute has an increased value, no plant can afford to have unnecessary delays and equipment failures caused by inadequate packings. That's why it is important to pack with Belmont—the packings that are pre-planned for service.

Below are two of the many Belmont Packings especially made for Oil Services, packings that will perform their tasks faithfully—even under the strain of 24-hour-day operations. Both Belmont 6100 and 189 are made from selected high grade asbestos yarn, braided, and treated with an exclusive lubricant for ultimate wear and greater efficiency.

The complete line of Belmont Packings (for all types of services) is illustrated and described in detail in Belmont Catalog No. 40. Write for a FREE copy on your company letterhead today! Any Belmont distributor will be glad to show you samples and help you with your particular packing requirements.

BELMONT PACKINGS

THE BELMONT PACKING & RUBBER CO. — BELMONT — PHILADELPHIA, U.S.A.

FOR
GASOLINE SERVICE
BELMONT 6100
For rod and valve stems handling volatile distillates such as gasoline, kerosene, naphtha, and benzol.
FOR
HOT OIL SERVICE
BELMONT 189
For rods and plungers handling hot or cold oil—all temperatures.

THE BELMONT PACKING & RUBBER COMPANY
BUTLER AND SEPVIVA STREETS • PHILADELPHIA, PA. ★

MANUFACTURERS' NEWS

Leonard F. Lang has been appointed to the newly organized Power Plant department of Western Precipitation Corp., Los Angeles, Calif., to have headquarters at 140 So. Dearborn St., Chicago, Ill. Mr. Lang is a member of A.S.M.E., and started in the combustion field with Underfeed Stoker Co. in 1917, then after war service was with Combustion Engineering Co. and Riley Stoker Corp., and for the past 12 yr. has been with Chicago office of Detroit Stoker Co.

O. A. Soderberg has been transferred from the Philadelphia District Office of Combustion Engineering Co., Inc., to become manager of the Detroit District Office, a place left open since W. J. Vogel was transferred to New York as Executive Engineer. Mr. Soderberg was graduated from Yale University in 1917, spent some time with the Winchester Arms Co., later enrolled in the schools conducted by the Navy in marine engineering and in turbines at Stevens Institute and Carnegie Tech., respectively, and from 1920 to 1932 he was employed by Griscom-Russell Co. in engineering and sales work and later. Prior to joining Combustion Engineering Co., he was with the Sun Oil Co.

L. W. Wallace, research and management engineer, has joined the staff of The Trundle Engineering Co. as vice president, it was announced today by George T. Trundle, Jr., president of the company. Before accepting his new position Mr. Wallace was director of engineering and research of The Crane Co., Chicago. Mr. Wallace has made special studies of many industrial and economic problems. His field of research has included transportation, patent office procedure, technological unemployment, civil aviation, traffic, and many other subjects.

Stanley W. Scarfe has been appointed Assistant Manager of General Electric Co., Los Angeles (Cal.) Central Station Department, as announced by S. E. Gates, Manager. Graduating from University of California in 1924, Mr. Scarfe became sales assistant in San Francisco, went to Schenectady in 1925 to take the student test course and sales training course, and in 1927 was placed in charge of sales at Fresno, Calif. In 1932 went to Sacramento in like capacity, from 1937 to 1939 was assistant to the manager in San Francisco, and then in the Los Angeles office.

Harry G. Johnson is now territorial salesman at Indianapolis, Ind., for Manning, Maxwell & Moore, Inc., of Bridgeport, Conn. He succeeds Gerald Beebe, who has been given extended leave of absence due to illness.

Clarence E. Scott has been appointed Sales Manager of the Air Conditioning Division of Fedders Mfg. Co., Inc., of Buffalo, N. Y. He graduated from University of Kentucky, then was with York Heating and Ventilating Corp., Carrier Corp. and Warren Webster Co. Mr. Scott takes the

A PATH FOR LUBRICATION

That's the Reason for

MORSE ROLLER CHAIN'S

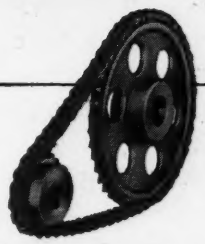
LONG LIFE and SMOOTH POWER

An ingenious and exclusive design puts positive lubrication in this roller chain and at the same time maintains its complete interchangeability with all other standard round-pin roller chains.

Channels at the ends of the bushings lead oil from rollers through the sideplates to the pin and bushing surfaces, provide a flow of life preserving lubrication for the heart of the roller chain, adding years of trouble-free life and smooth, efficient operation.

Morse Roller Chains are built to save you money, trouble, and time. Special alloy steels, heat treated to fit the demands of each part of the chain, are used in manufacturing these better chains. Expert workmen build *service* into them. The exclusive design is simple as can be—and as effective as it is simple.

Morse Roller Chain—with "force feed" lubrication—is made in all sizes and capacities and in single and multiple widths. Call your nearest Morse representative, or write direct to Morse, Ithaca.



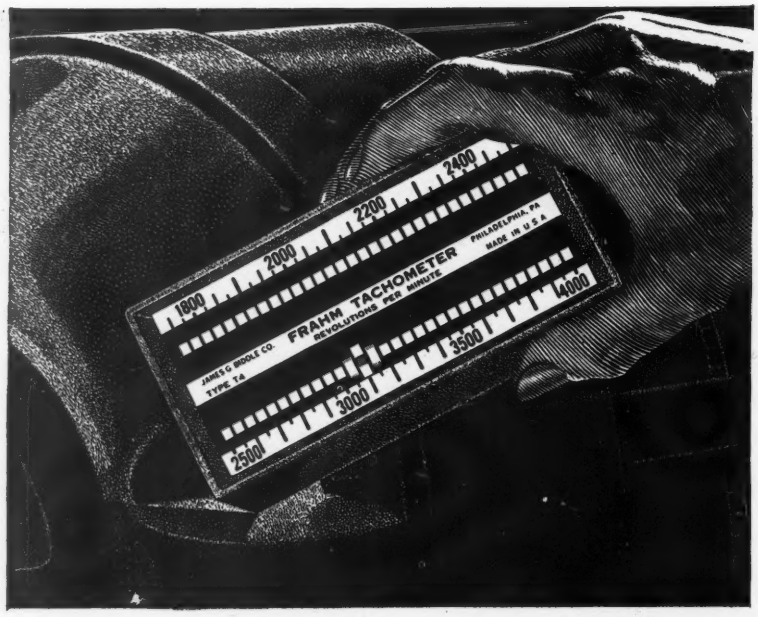
OIL Gets IN WEAR Stays OUT

No longer do Roller Chains "work their hearts out" on the job. For in Morse Roller Chain the heart of the chain is protected with a life-preserving film of oil, flowing there through channels from the bushings. Oil gets in—wear stays out!

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP



Measure Speed — Simply by Touch

Consider the advantages of a Portable Hand Tachometer that does not even "see" the rotating shaft, that has no wearing parts or pointer, that requires no belts, gears or electrical connections and that cannot lose its calibration through lack of oil or over-speeding.

Simply hold the Frahm Tachometer against some stationary part of the machine under test. Almost immediately one of the calibrated reeds begins to vibrate and the corresponding point on the scale shows the speed.

It works by mechanical resonance. Slight vibration of the machine passes into the instrument through the point of contact and the particular reed which is in tune goes into responsive vibration.

This unique device may help to solve your speed-measuring and vibration problems. Made for both hand use and for permanent mounting, ranges from 900 up to 30,000 r. p. m.

Write for Bulletin 1590PE

JAMES G. BIDDLE CO.

1211-13 Arch Street, Philadelphia, Pa.

"FRAHM" Vibrating Reed TACHOMETER

place of Edmund R. Walker who is now Assistant General Manager of the Fedders Co.

G. C. Walker has been appointed Sales Manager for The Bird-Archer Co. of New York City. He was formerly New York District Manager for W. H. & L. D. Betz. H. C. Stevens, also previously with the Betz organization, is now assigned to Connecticut territory for The Bird-Archer Co.

S. E. Tray has been appointed acting manager of the Feedwater Treating Department of The Allis-Chalmers Mfg. Co., effective September 1. Mr. Tray, Assistant Manager of this department for the past 3 yr., joined the Allis-Chalmers organization at the time the Feedwater Treating Department was formed in 1932 and now succeeds Otto H. Falk, Jr., who has resigned.

Blanchard Smith

CHAPLIN-FULTON Mfg. Co. of Pittsburgh, Pa., announces that it will be represented in the Mid-Continent territory by Blanchard Smith, who formerly represented the Reynolds Gas Regulator Co. Mr. Smith was also for years connected with Westcott & Greis, Inc., of Tulsa, Okla. His new territory, including Iowa and Nebraska on the north and Lousiana and Texas on the south, will comprise eight states, with headquarters in Kansas City, Missouri.

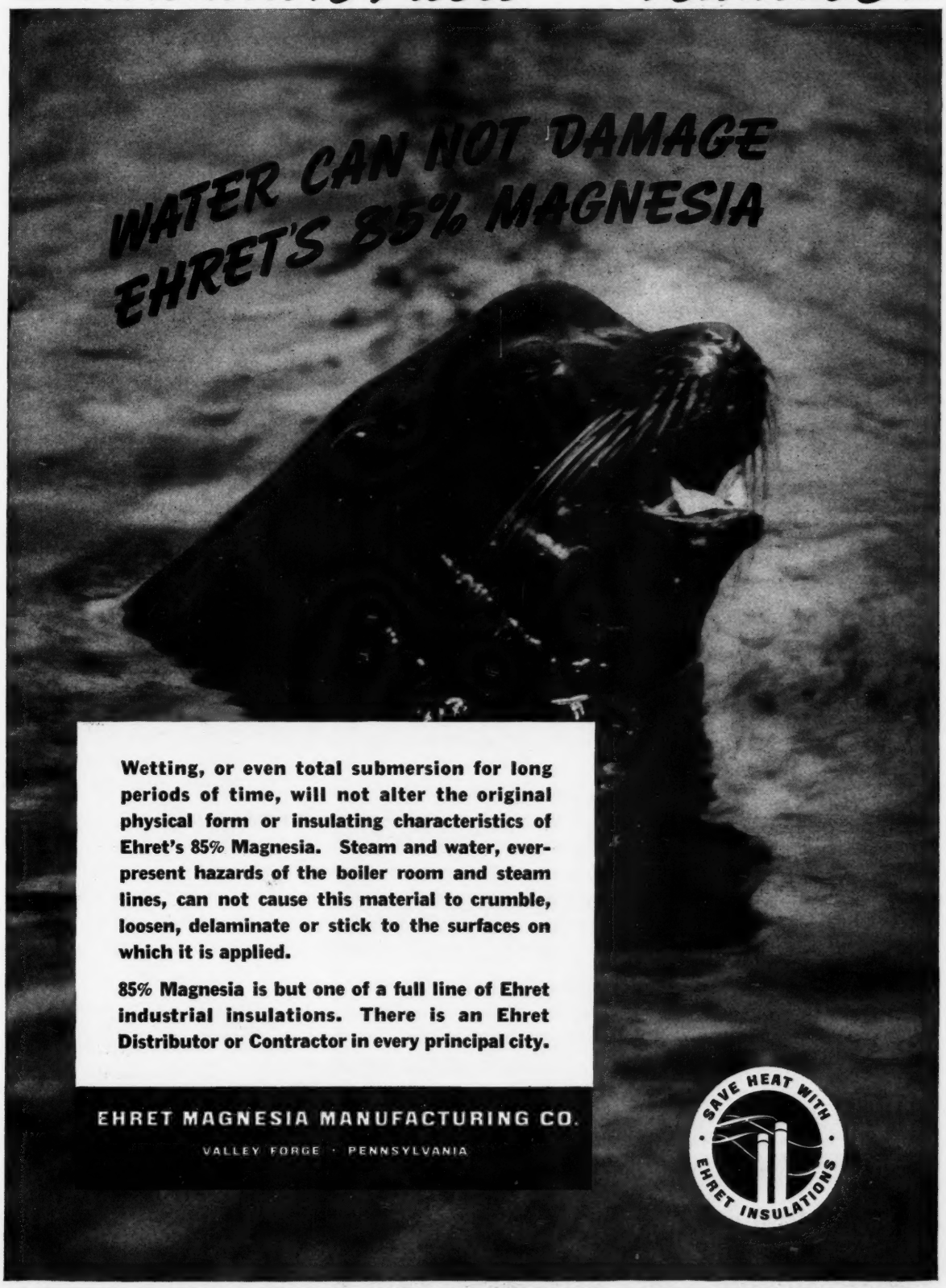
Blanchard Smith

Gordon LeFebvre Joins Cooper-Bessemer

COOPER - BESSEMER CORP. has announced that at a meeting of its board of directors on August 25, Gordon LeFebvre, former American Locomotive Co. executive, was elected its vice-president and general manager, to fill a vacancy created in May by the untimely death of Charles B. Jahnke. B. B. Williams who was called at that time to resume active duties as head of the corporation, will retain the positions of president and chairman of

Gordon LeFebvre

Insulation Facts · Number 5.



Wetting, or even total submersion for long periods of time, will not alter the original physical form or insulating characteristics of Ehret's 85% Magnesia. Steam and water, ever-present hazards of the boiler room and steam lines, can not cause this material to crumble, loosen, delaminate or stick to the surfaces on which it is applied.

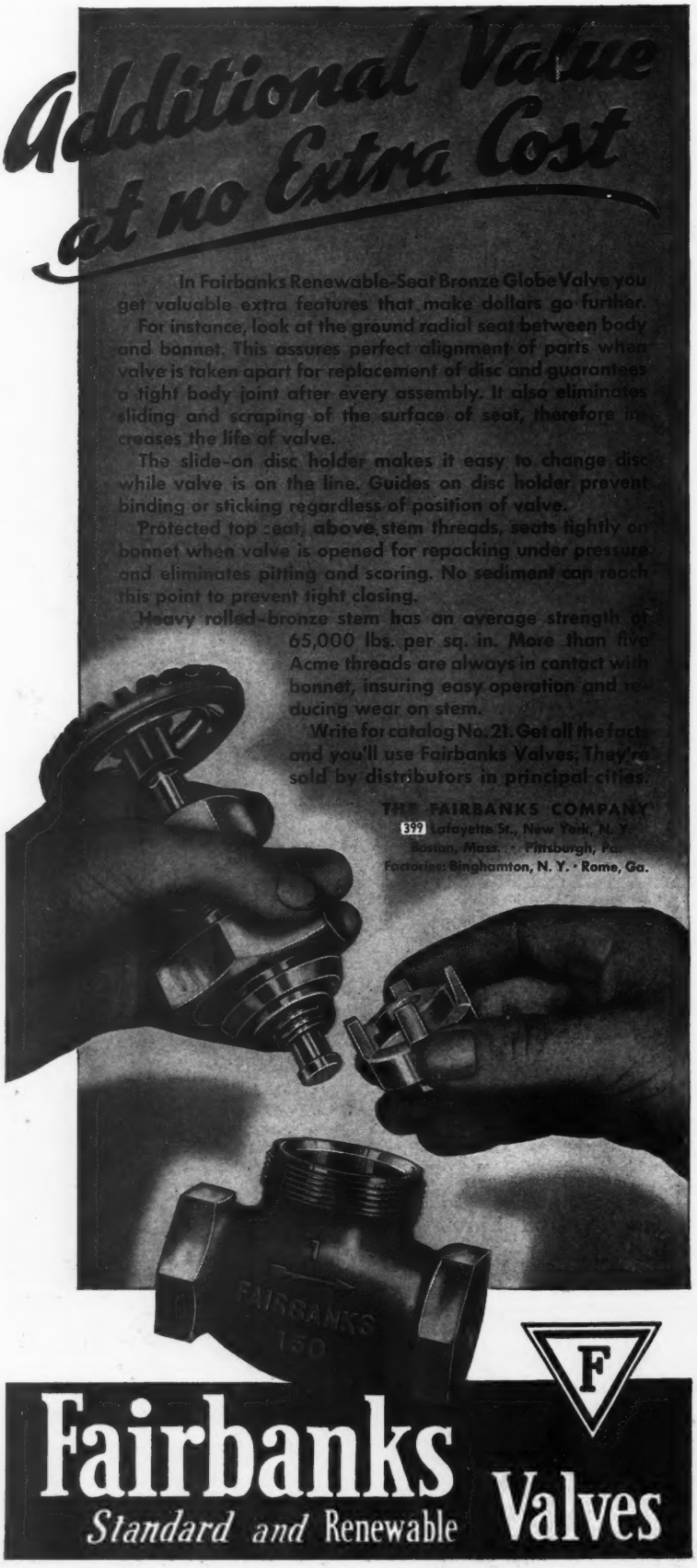
85% Magnesia is but one of a full line of Ehret industrial insulations. There is an Ehret Distributor or Contractor in every principal city.

EHRET MAGNESIA MANUFACTURING CO.

VALLEY FORGE · PENNSYLVANIA

SAVE HEAT WITH EHRET INSULATIONS

MAKERS OF INDUSTRIAL INSULATIONS FOR MORE THAN 40 YEARS


Additional Value at no Extra Cost
In Fairbanks Renewable-Seat Bronze Globe Valve you get valuable extra features that make dollars go further.
For instance, look at the ground radial seat between body and bonnet. This assures perfect alignment of parts when valve is taken apart for replacement of disc and guarantees a tight body joint after every assembly. It also eliminates sliding and scraping of the surface of seat, therefore increases the life of valve.
The slide-on disc holder makes it easy to change disc while valve is on the line. Guides on disc holder prevent binding or sticking regardless of position of valve.
Protected top seat, above stem threads, seats tightly on bonnet when valve is opened for repacking under pressure and eliminates pitting and scoring. No sediment can reach this point to prevent tight closing.
Heavy rolled-bronze stem has an average strength of 65,000 lbs. per sq. in. More than five Acme threads are always in contact with bonnet, insuring easy operation and reducing wear on stem.
Write for catalog No. 21. Get all the facts and you'll use Fairbanks Valves. They're sold by distributors in principal cities.
THE FAIRBANKS COMPANY
Lafayette St., New York, N. Y.
Boston, Mass. • Pittsburgh, Pa.
Factories: Binghamton, N. Y. • Rome, Ga.
FAIRBANKS 150
F
Fairbanks
Standard and Renewable
Valves

the board of directors. At the same meeting, Mr. LeFebvre and L. F. Williams, were elected directors of the corporation.

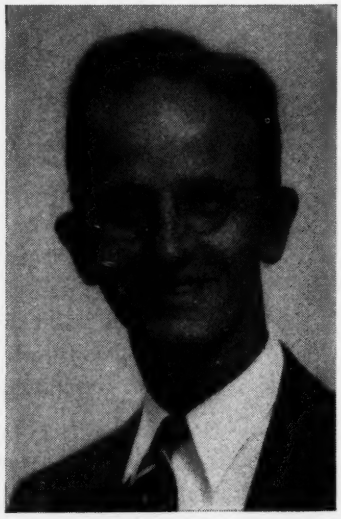
Mr. LeFebvre is a graduate of Virginia Polytechnic Institute and attended the United States Military Academy at West Point, N. Y. From 1913 to 1914 he served as a special apprentice and machinist for the Northwestern Railway. During the years 1915 to 1919 he was affiliated with E. I. Dupont de Nemours & Co. as machinist, master mechanic, and finally, mechanical superintendent.

In 1919 Mr. LeFebvre became associated with General Motors Corp. at its Chevrolet Division. He was in charge of construction of the Chevrolet plant and, later, responsible for production there, under Wm. S. Knudsen. He was then promoted to the position of vice-president in charge of all General Motors Corporation activities in the Dominion of Canada, returning to the United States to assume the duties of vice-president in charge of operations at the company's Pontiac Division.

From 1932 to 1936 he was a consulting engineer with offices in Detroit, Michigan, eventually becoming associated with A. J. Brandt, Inc. In 1937, he joined the American Locomotive Co. as manager of its Diesel Engine Division at Augurn, New York, and served in that capacity until coming to this new position with The Cooper-Bessemer Corp.

A. K. Hegeman

A. K. HEGEMAN has been appointed manager of a new west coast office for Clark Bros. Co., Inc., of Olean, N. Y., as announced by J. B. Connor, vice-president. The new office will be located at Pacific Pump Wks., Bicket St. and Slauson Ave., Huntington Park, Cal., with Art Rowe in charge of service, warehouse and repairs.



A. K. Hegeman

Westinghouse Changes

D. W. R. MORGAN, George P. Passmore, and A. P. Craig will supervise increased expansion and production activities in the Westinghouse South Philadelphia Works. Mr. Morgan will direct

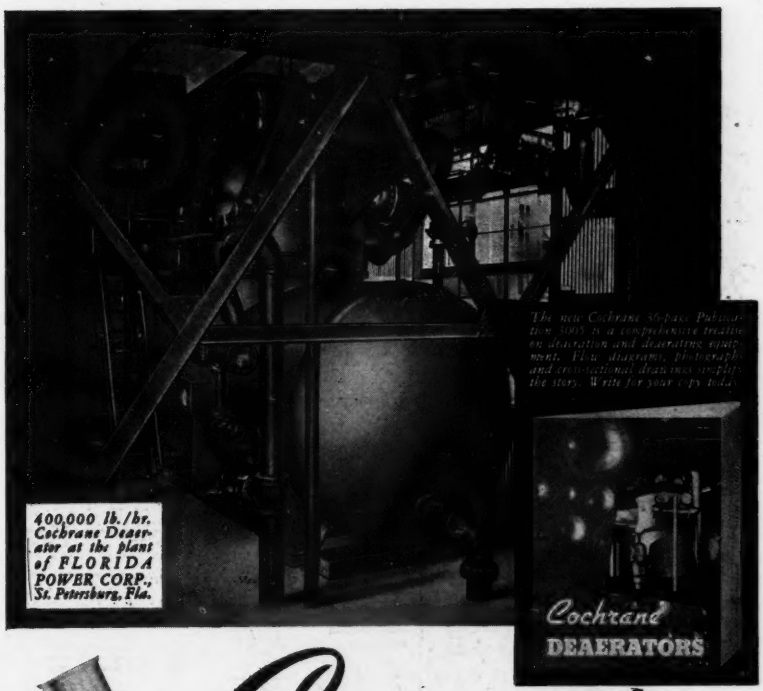
MORE POWER?

One Solution to an Urgent Defense Problem

WITH government experts estimating a power shortage in the program they have laid out for the next two years, the addition of new plants and the expansion of present plants seem inevitable.

COCHRANE equipment and engineering experience can assist in the expansion of power plant facilities through the increased efficiency made possible by modern feedwater conditioning, continuous boiler blowdown steam purification, efficient condensate drainage and effective boiler room instrumentation; and in adapting such equipment to present plant facilities.

Consult a Cochrane representative when planning plant expansion or when erecting a new plant.


400,000 lb./hr. Cochrane Deaerator at the plant of FLORIDA POWER CORP., St. Petersburg, Fla.
The new Cochrane 56-page Publication 5005 is a comprehensive treatise on deaeration and deaerating equipment. Flow diagrams, photographs and cross-sectional drawings amplify the story. Write for your copy today.
Cochrane DEAERATORS

Cochrane Corporation

3123 N. 17th ST. **PHILADELPHIA, PA.**

WATER SOFTENERS • DEAERATING HEATERS • DEAERATORS • BLOW-OFF EQUIPMENT • VALVES • FLOW METERS

FYR-FEEDER is the Modern Spreader Stoker

Sectional view of 6-burner FYR-FEEDER Spreader Stoker.

The Stoker with FEATURES which Engineers WANT and DEMAND!

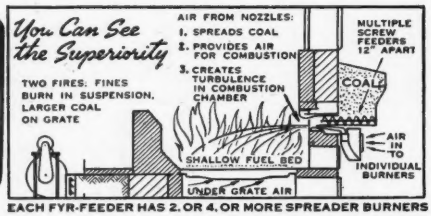
1. **FYR-FEEDER SPREADER STOKER'S ADVANCED DESIGN makes it the MODERN Spreader Stoker. Developed and engineered to fire boilers rated from 50 h.p. up, with maximum efficiency. Only 2" air pressure used by air nozzles for spreading coal over average size grates.**

2. **FYR-FEEDER SPREADER STOKERS BURN CHEAPEST COAL, wet or dry. Users report saving up to as much as $4.00 per ton by using local screenings, yard sweepings, etc. FYR-FEEDER handles fluctuating loads with ease.**

3. **FYR-FEEDER SPREADER STOKER PRODUCES EXCELLENT COMBUSTION, due, in part, to its perfect coal distribution over grates. Fines burn in suspension—larger coal on grate. Air from nozzle under each feeder (1) spreads coal, (2) provides the necessary overfire air required for completion of combustion and (3) creates turbulence in furnace. FYR-FEEDERS always have 2, 4, or more, feeders.**

4. **FYR-FEEDER SPREADER STOKERS ARE OPERATED WITH A THIN FUEL BED. FYR-FEEDER firing never requires a thick fuel bed or a large mass of coal in the furnace. Therefore, fuel is not wasted when load drops off. In cleaning, fire is allowed to burn out completely on one side of the grate while firing continues uninterruptedly on the other side. For complete information, use coupon below.**

Fyr-Feeder MULTI-BURNER STOKERS


You Can See the Superiority
AIR FROM NOZZLES:
1. SPREADS COAL
2. PROVIDES AIR FOR COMBUSTION
3. CREATES TURBULENCE IN COMBUSTION CHAMBER
MULTIPLE SCREW FEEDERS 12" APART
TWO FIRES: FINES BURN IN SUSPENSION, LARGER COAL ON GRATE
COAL
AIR IN TO INDIVIDUAL BURNERS
SHALLOW FUEL BED
UNDER GRATE AIR
EACH FYR-FEEDER HAS 2, OR 4, OR MORE SPREADER BURNERS

AMERICAN COAL BURNER CO., 153 E. Superior St., Chicago, Ill.
I am interested in your FYR-FEEDER Spreader Stoker because I think it is the best stoker built.

I WANT TO—
- ☐ Buy them
- ☐ Sell them
- ☐ Install them
- ☐ See an installation
- ☐ Look over literature

Name .....
Company .....
Address .....

over-all manufacturing operation, both in the South Philadelphia Works and the new merchant ship equipment shops. Mr. Passmore takes charge of the industrial relations department. A major portion of his new duties will be concerned with securing new employes, and co-operating with the manufacturing department in the plant's extensive training program.

Mr. Craig will be responsible for coordinating the work of all company departments in building and equipping the merchant ship factory building. He has been engaged in supervising plans and construction of Navy Ordnance plants being built by Westinghouse in Canton, O. and Louisville, Ky.

T. G. Glenn Succeeds T. E. Nicoll

TRUMAN G. GLENN, formerly assistant district engineer in the General Electric Co.'s Central District, has been appointed Engineer of the Detroit office, succeeding Thomas E. Nicoll, who retires October 1, under the company's Pension Plan, after more than 38 yr. with the company.

Mr. Glenn, a native of Chilton, Wisconsin, graduated from the University of Wisconsin in 1922 in mechanical engineering, soon joining the General Electric Co. as a student in the Test Course. In July, 1923, he was transferred to Chicago as outside construction foreman, and after 2 yr. of general engineering work, was appointed assistant district engineer, a position which he retained until his appointment to Detroit.

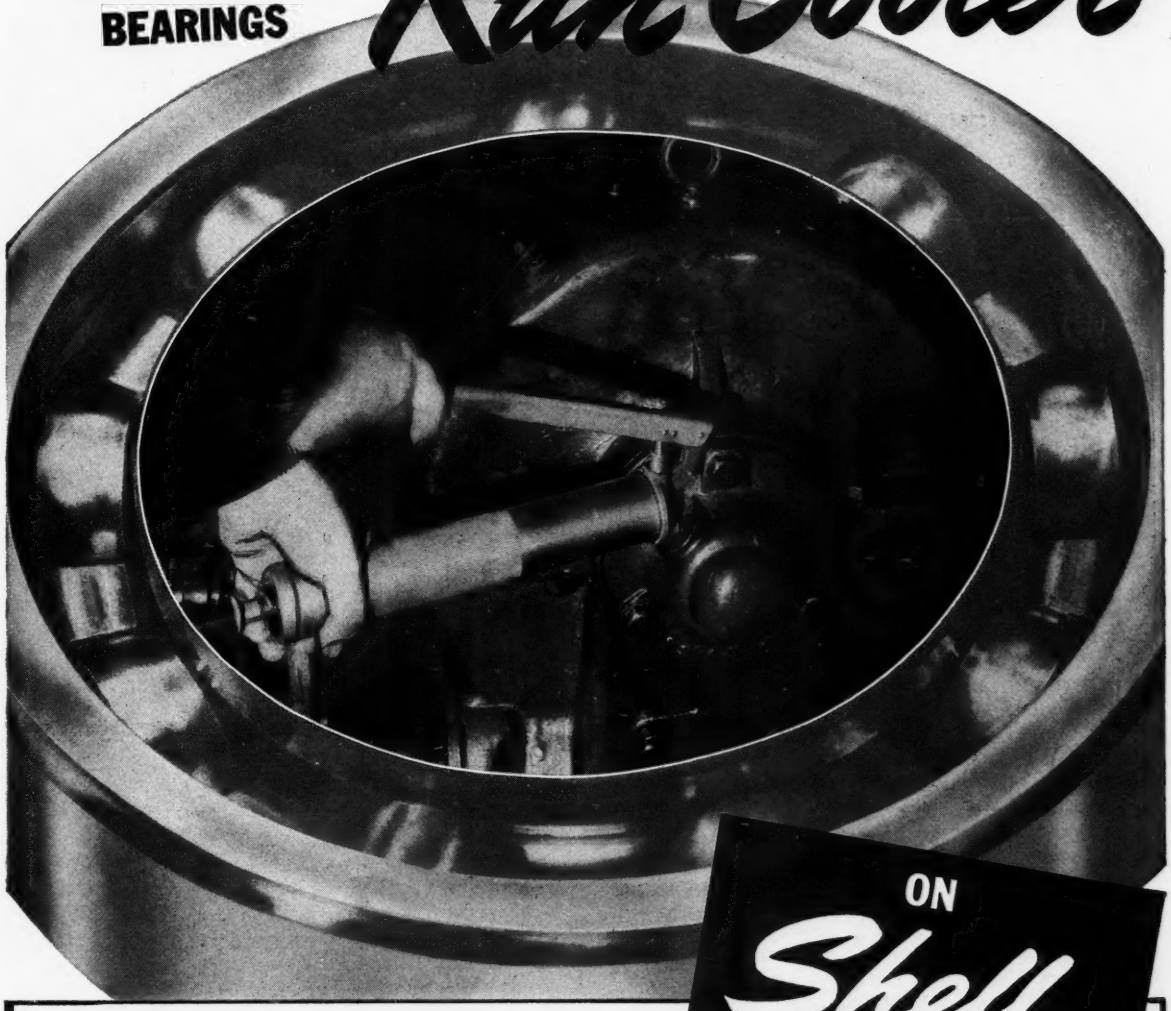
Mr. Nicoll, born in De Witt, Iowa, joined the General Electric Co. as a test student in 1903, after graduating from the Iowa State College in 1900 in electrical engineering. In November, 1905, he was transferred to the Chicago outside construction department, later to the engineering department, then was appointed Local Engineer of the St. Louis office on December 1, 1911. On December 1, 1916, after another brief spell in Chicago, Mr. Nicoll became local engineer of the Detroit office, serving in that capacity until his retirement.

Crane Co. Advances Officials

Crane Co. on August 25 elected J. L. Holloway vice president in charge of finance. Mr. Holloway joined the Crane organization in 1935, was elected secretary of the company in 1937 and, in addition, was appointed assistant to the president in 1940, which positions he held until his election as vice-president. Mr. Holloway interrupted his studies in engineering at the University of Manitoba to go to France with the Canadian forces during the last war; then entered the accounting field, becoming a chartered and certified public accountant, in which capacity he had an extensive experience covering practically every phase of operation in a great variety of corporations.

At the same meeting of the Board, W. H. Winslow, Jr., was elected secretary. He joined the Crane organization in 1939 to handle tax and legal matters for the company, and has been assistant secretary since early in 1940. He was with the American Army in France during the last war, following which he resumed the study of law, was admitted to the bar, and practiced law as a member of well-known law firms.

ANTI-FRICTION BEARINGS *Run Cooler*



ON *Shell E.X.L. Grease*

– more lubrication per pound

SHELL

SHELL E. X. L. Grease is able to retain its superior lubrication characteristics under the most severe operating temperatures . . . readily dissipates the heat caused by deformation. Here's why. Shell E.X.L. Grease . . .

1—Has a high melting point.
2—Is of a smooth texture . . . lubricates adequately.
3—Resists bleeding . . . does not separate at high rotational speeds or at high temperatures.
4—Is non-corrosive.
5—Has outstanding resistance to breakdown even at high operating speeds.
6—Seals bearings against entrance of dirt, water, etc.

Call in the Shell man today. Give him the toughest bearing lubrication job you've got. Watch him lick it.

• PIPING •

1 Pipe from pump, never to pump
2 Larger pipe than pump suction
3 Short, straight suction line
4 Piping supports relieve pump strain

Suction and discharge piping should start from the pump and not be brought to it. The reason for this is that if the pipe is brought to the pump and the last piece cut too short or too long it will produce a strain on the pump, causing rotor wear, and stuffing box leakage. When piping connections have been made, neither the suction nor discharge pipe should produce any strain whatever on the pump body.

Horizontal screw pumps are provided with two suction connections; either or both sides may be used. Vertical screw pumps, Rotex and centrifugal pumps usually have only one suction connection. Make all suction lines as short and as straight as possible to prevent air pockets. Use suction lines larger in size than the pump suction (never smaller). A successful pump installation requires a carefully planned suction line to reduce friction and suction lift to the minimum.

Proper supports should be provided for the piping. It should not be supported or carried by the pump. It should be possible to turn all Rotex and centrifugal pumps, and screw pumps up to size number six, by hand by turning the shaft coupling. Screw pumps larger than size number six should turn easily with the aid of a small bar. The pump should revolve easily and smoothly at all points of the revolution after it is permanently connected. If pump is not free to turn easily—don't start it.

Suitable pressure relief valves should be placed in the discharge lines of rotary pumps at any convenient points, with by-pass lines led back to the supply tanks. Only water pumps operating from a main should be by-passed through relief valves back into the suction line. Centrifugal pumps do not require relief valves.

CONCERNING DELIVERY: National Defense priority may cause even our oldest customers some delay in delivery. We earnestly request your patient cooperation until our present expansion program can relieve this situation.

QUIMBY PUMP CO.
INC.
352 THOMAS STREET
NEWARK, N. J.

QUIMBY SCREW PUMPS

. . . GOOD PUMPING PRACTICE SINCE 1894 . . .

OBITUARIES

Clarence H. Kennedy

C. H. Kennedy

CLARENCE H. KENNEDY of the Kennedy Valve Mfg. Co., died on July 21 after an 8 mo. illness. He was 51 yr. old.

Born in Brooklyn, N. Y. in 1890, Mr. Kennedy graduated from Cornell as Mechanical Engineer in 1912, and has spent his business career with Kennedy Valve Mfg. Co., which was founded by his father, Daniel Kennedy in 1877. Working through the ranks in various departments, he became New York Branch Manager and, since 1929, Vice President in charge of Sales.

Drafted by President Roosevelt, he worked in re-employment campaigns for national recovery. He was a prominent member of Elmira Council, Knights of Columbus and other Catholic organizations. His brothers, Matthew E. Kennedy, President of the Company and John Carroll Kennedy, Vice President in charge of production, will carry on.

John Morse

John Morse

JOHN MORSE, son of Colonel Robert H. Morse, President of Fairbanks, Morse & Co. met an untimely death August 22nd when the car in which he was a passenger collided with a bus during a dense fog on the approach of the Golden Gate Bridge at San Francisco, Cal. He was 25 yr. of age, graduated from Yale in 1937, and, since last April, when he resigned from the U. S. Navy because of an eye deficiency, had been assistant manager of the company's San Francisco Branch.

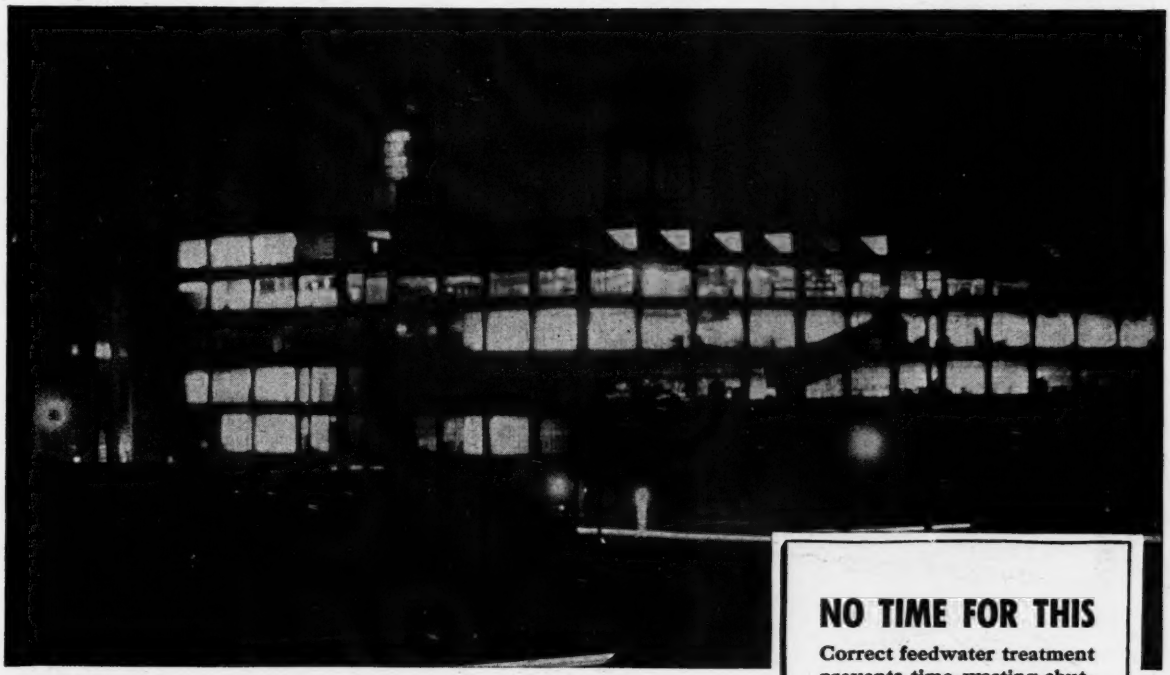
Harold Stein

Harold Stein

HAROLD J. STEIN, 47, director of research, chemistry and metallurgy at the Allis-Chalmers Mfg. Co. since 1939 when they were consolidated into one department upon the retirement of R. S. MacPherran, chief chemist, died September 9.

Mr. Stein started with Allis-Chalmers as a student apprentice in 1916, served in various departments and in 1936 he was made chief research engineer of all the manufacturing departments. He was born in Philadelphia, Pa., the son of Joseph Stein, superintendent of the experimental station at the naval academy, Annapolis. He attended Tri-State college at Angola, Ind.

For "all-out" production—your boilers MUST stay in service!



Prevent scale—and shutdowns—with PERMUTIT* conditioned feedwater

Even under ordinary conditions it is important that feedwater treatment exactly fits your own plant requirements. Under the strain of continuous defense production, it is imperative!

During this period of "stepped-up" power-loads, thousands of steam plants are relying upon "Water Conditioning Headquarters" to give them complete protection against boiler scale and corrosion. Permutit provides every process for conditioning feedwater . . . Permutit installations are treating every variety of raw water, every feedwater volume up to millions of gallons daily.

Why not let Permutit work with your engineers to insure top efficiency at your plant? Write us about your problem or ask for free booklets: The Permutit Company, Dept. A1, 330 West 42nd Street, New York, N. Y. * Trademark Reg. U. S. Pat. Off.

NO TIME FOR THIS

Correct feedwater treatment prevents time-wasting shutdowns to clean boilers, repair or replace choked up superheaters and feed lines.

PERMUTIT

WATER CONDITIONING HEADQUARTERS

DART UNIONS REACH A RIPE OLD AGE

DART UNIONS still have lots of life after giving lots of service . . . they *still* make tight quickly and stay tight permanently even after having been re-installed time and again. There is no mystery about it all—Darts simply give to you, the advantages that have *been built right in to them* . . . advantages such as extra-heavy bodies and nuts, made from air refined malleable iron and matched bronze seats, ground to Dart's exclusive true-ball joints. Naturally, Dart Unions can reach a ripe old age and put up such strong resistance to pipe strains, abuse and corrosion.

Just specify size and model and we will send you a Dart Union, free.

DART UNIONS

E. M. DART MFG. CO., PROVIDENCE, R. I.

Sales Agents: The Fairbanks Company New York, and all branches
Canadian Factory: Dart Union Company, Ltd., Toronto, Canada

Dr. D. B. Snively

DR. D. B. SNIVELY, a Director of Frick Co. for the past 40 years, passed away at his home in Waynesboro on August 28, 1941. He served on many important committees of the Board of Directors, was a member of the executive committee, and active in the work of the credit department. He was also a Director of the Knickerbocker Stamping Co. and Director and Vice President of the Citizens National Bank & Trust Co.

Charles H. Roberts

CHARLES H. ROBERTS, treasurer of Johns-Manville Corp., died September 10, at Doctor's Hospital where he had been confined since August 20 for treatment of a heart ailment. Mr. Roberts was 51 yr. old and lived in Scarsdale, N. Y.

Born on a farm near Doylestown in Bucks County, Penna., on May 8, 1890, Mr. Roberts received his secondary education in Trenton, N. J., and attended the Wharton School of Finance of the University of Pennsylvania until 1907, when he began his business career with J. A. Roeblings Sons Co., as head of their cost department.

Later he served in various capacities in the financial departments of the Mercer Automobile Co., Hess-Bright Manufacturing Co., U. S. Rubber Co., Splitdorf Electrical Co., and Julius Kayser & Co. before joining Johns-Manville in 1928 as assistant general auditor. In that same year he was made general auditor. In 1937 he became comptroller and the following year was appointed treasurer.

NEWS FROM THE FIELD

On the Heidelberg Hotel plant at Jackson, Miss., we are informed that E. W. Bullock of the Fly Ash Arrestor Corp., Birmingham, Ala., is the engineer on the installation. He is a graduate of Georgia Tech, with several years experience with Alabama Power & Light Co. and has on his own account installed several plants in the southern states.

Interconnection between facilities of Alabama Power Co. and Florida Power Co. is to be made from substations at Pinckard, Ala., and Quincy, Fla., via Gulf Power Co. substation at Graceville, Fla., and facilities to be constructed at Marianna, Fla. The order of Federal Power Commission provides for a 110,000 v. line, construction of line and control facilities to be started immediately.

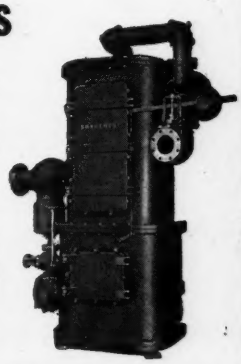
Charles E. Wangeman has been appointed head of the Bureau of Placements at Carnegie Institute of Technology, Dr. Robert E. Doherty, president, as announced recently, to replace John D. Beatty, resigned.

Simplified practice for copper conductors, given out by the National Bureau of Standards, lists 17 sizes from No. 14 A.W.G. to 500,000 cir. mils. The object is to reduce inventories of slow moving sizes. Mimeographed copies are available from Bureau of Standards, Washington, D. C.

Cut Boiler Maintenance Costs

with Guaranteed Quality Feed Water supplied by

Swartwout Heaters



● It pays to provide adequate preheating, deaerating and purifying of the water you feed to your boilers. Reduce costly boiler cleaning and corrosion, and *excessive fuel consumption* with *oxygen-free* hot water assured by Swartwout Heaters correctly engineered to fit your needs.

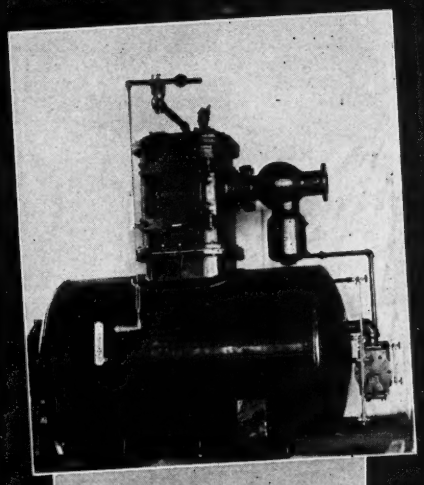
Swartwout high quality standards of engineering, workmanship and materials are known to hundreds of satisfied users. Write today for Bulletins S-18-D and S-193.

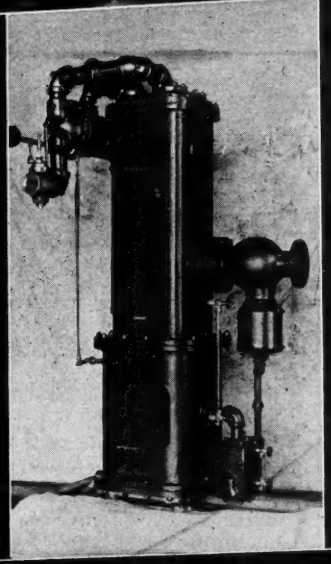
THE SWARTWOUT CO., *18501 Euclid Ave., Cleveland, Ohio*

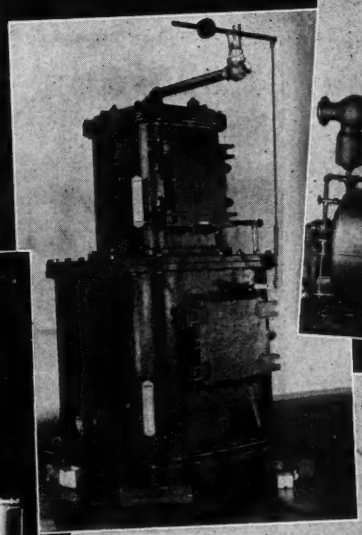
Feed Water Regulators • Pump Governors • Feed Water Heaters
Master Controls • Reducing Valves • Separators • Exhaust Heads

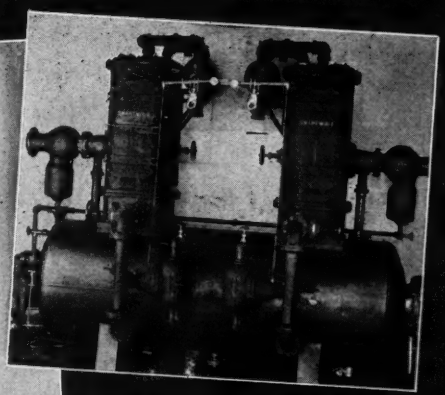
Swartwout

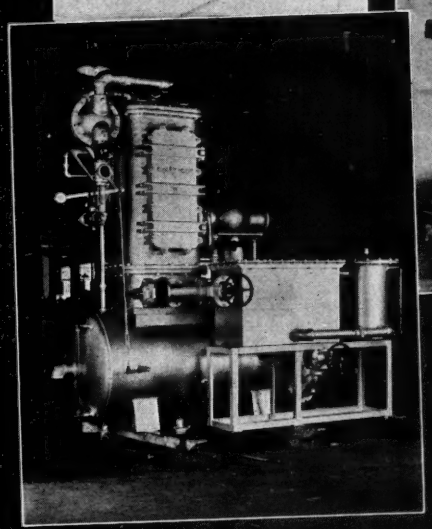
•Power Plant Equipment•

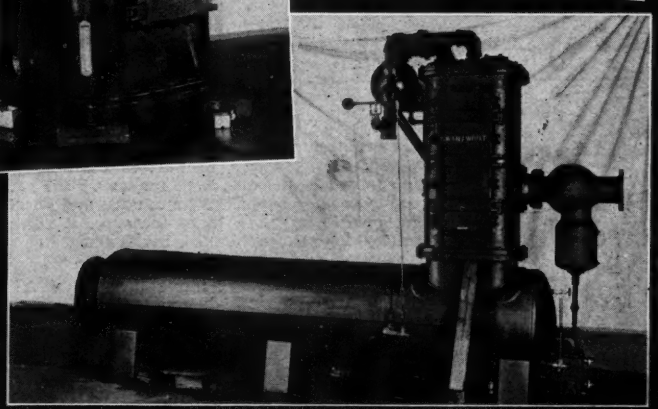












ROTO is glad to report BUSINESS HAS FALLEN OFF on tube cleaner repairs.....

Model 109 air-driven motor with swing-frame head.

Ever since we began deliveries of the current type Roto Tube Cleaners five years ago, our repair business has been dropping steadily, despite a large increase in total sales volume.

More efficient design and more durable materials have reduced upkeep and operating costs very materially. But entirely apart from lower maintenance cost, the new Roto reduces cleanout time so greatly that hard-pressed plants find it more economical to buy the new Roto and lay aside slower, old type cleaners for standby service.

It will pay you to get full details about the new Roto.

See Our Adv. in Sweet's and Write

The ROTO Company
145 Sussex Avenue
NEWARK, N. J.

ROTO
Tube Cleaners

Today's Fight

For Success

• •

To engineers, managers and stockholders of any manufacturing plant or service establishment, the power plant equipment makes up the weapons in today's battle for continuous and successful operation. In a large measure, it controls improvements, economies, dividends.

To gain success and move forward with the great power plant industry calls for a broadened knowledge on the part of operating engineers and managers in the value of the modern methods and equipment as described in the advertisements of this and other issues of **POWER PLANT ENGINEERING.**

J. G. White Eng. Corp. recently announced that Robert H. Barclay, since 1936 New York Regional Director of the Federal Power Commission, has ben engaged as electrical engineer in charge of the Division of Electrical Engineering. From 1908 to 1917 Mr. Barclay was engaged in miscellaneous telephone and transit work, as chief electrical engineer for The Foundation Co. and Starrett & Van Vleck, architects, and electrical engineer for the Stone & Webster Eng. Corp. From 1931 to 1934 he was president of the McClelland Barclay Art Products, Inc., and in 1934 became affiliated with the Federal Power Commission, Washington, D. C., as Chief of the analysis and reports division of the National Power Survey.

Food Preservation Conference will be held at Univ. of Tenn., Knoxville, Oct. 23-25, under auspices of A.S.R.E. and the direction of J. Mack Tucker. Sessions will cover afternoon of Oct. 23 to evening of Oct. 24, the main topics being Refrigeration in Defense, Operation and Equipment of Locker Storage Plants, Equipment and Refrigerants for Quick Freezing. Oct. 25 will be devoted to scenic trips and football.

Wisconsin Rapids, Wisc., has given notice of intention to build a hydroelectric development on the Wisconsin River in Portage Co., with earth-fill dam 6900 ft. long and concrete power house section 600 ft. long for 7200-kw. capacity, with reservoir 6400 acres in area.

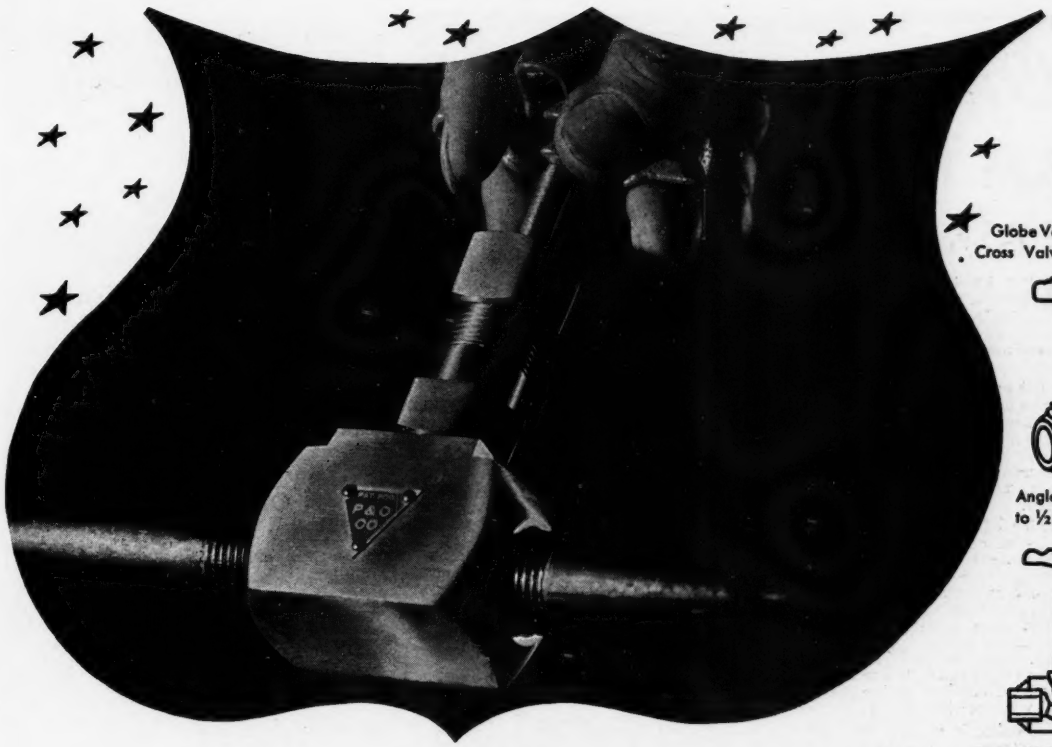
The Assel seamless tube piercing mill, invented and developed by The Timken Roller Bearing Co., has been converted into a shell mill which produces shells twice as fast as the conventional forging methods now in use.

Fuels Meeting in Easton

Joint meeting of the A.I.M.E. Coal Division and A.S.M.E. Fuels Division will be at Easton, Pa., Oct. 30 to Nov. 1. Headquarters will be in Hotel Easton, and the theme will be Better Utilization of Coal. Among papers to be presented will be: Domestic Stoker Coal Research by Walter Knox of Koppers Co. on Thursday morning; Pulverized Fuel Burning Equipment, a symposium by Henry Kreisinger, Combustion Engineering Co., by A. C. Foster, Foster-Wheeler Corp., by F. G. Ely, Babcock & Wilcox Co. and by Ollison Craig, Riley Stoker Corp.

On Thursday afternoon, contributions on Underfeed Stoker Equipment; on Thursday evening by Geo. P. Jackson, Combustion Engineering Co., J. S. Bennett 3rd, American Engineering Co. and by R. A. Foresman, Westinghouse Elec. & Mfg. Co.; Friday afternoon, papers by J. M. Heinek of Philadelphia on Industrial Chain Grate Stokers and by C. H. Frick of Allentown on Pulverized Anthracite in Steam Power Plants.

At the Friday evening banquet, E. G. Bailey, vice president, Babcock & Wilcox Co., will speak on Better Utilization of Coal, with motion pictures of stoker fired fuel beds by Consolidated Edison Co. of New York. William G. Christy, Chairman Fuels Division, A.S.M.E., and J. E. Tobey, Chairman Coal Division, A.I.M.E., will be in charge of the meeting.



Globe Valves ⅛" to 1". Cross Valves ¼" only.

Angle Valves ⅛" to ½".

Socket Welding End Type same price as threaded.

THEY STAND THE DRIVE OF DEFENSE PRODUCTION

You get a *plus* with Reading-Pratt & Cady Bar Stock Valves—a mighty important plus, due to the restrictions on the use of metals needed for emergency production.... You get *strength of bar stock metals* and strength of *stems, far heavier* than might seem required—security of *pipe threads of greater length* than the effectives required by A.S.A. and A.P.I. standards.... Today, it is *more* than good business or engineering to use valves of such rugged character that they stand the drive of defense production—put far into the future the day when their wearing out will call for the use of vital metals to replace them.

Lock Bonnet Type.

Indicator Type.

Thru-Port Type ¼" to ¾". Use where liquids carry solids in suspension. For Refinery lines, where coking makes frequent cleaning necessary.

SIZES: Up to 1".... **MATERIALS:** Bronze, Carbon Steel, 12:14 Chrome Stainless and 18:8 Chrome-Nickel Stainless—the latter available only for defense requirements.... **DESCRIPTION:** Globe, Cross and Angle Valves of Plug type. Turned from high grade bar stock of above metals and combinations of them as required by service.... **ACCURATE, CLOSE CONTROL:** Especially long seating contact. Fine spindle threads. Passage diameters of sizes to keep pressure drop to a minimum.... **SERVICES: Bronze,** 500 lbs. at 150° F. For air, gas, water, oil, etc.... **Carbon Steel,** in ¾" and 1" sizes, seat rings and disc are 12:14 Chrome Stainless. Ratings: 4000 lbs. at 150° F. to 475 lbs. at 1000° F. For non-corrosive services such as oil, gases and liquids at high pressure and temperature.... **12:14 Chrome Stainless:** Rating: 4000 lbs. at 150° F. Not suited for higher temperatures. For lines carrying fluids such as cold nitric, crude oil, alcohol, ammonia liquor, soap, boric acid, alkaline solutions, mine water, paints, ethyl gasoline, etc.... **18:8 Stainless:** Rating: 4000 lbs. at 150° F. Not suited to higher temperatures. Resist corrosion of 50% acetic, alum; 20% Sodium Hydroxide; saturated solution Calcium Chloride; moist Hydrogen Sulphide, sea water; food stuffs; carbonic acid; citric acid; sour oils and gases, and many other chemical solutions.... Combinations of these materials and the use of Stellite Discs make it possible to secure valves recommended for the more severe throttling services with steam, water and other fluids—4000 lbs. at 150° F. to 475 lbs. at 1000° F.

★

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PRATT & CADY: BRASS AND IRON VALVES
D'ESTE: VALVE AND ENGINEERING SPECIALTIES

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READING, PENNSYLVANIA

A Division of **AMERICAN CHAIN & CABLE COMPANY, INC.**

THE *Only* STEAM TRAP WITH ALL 4 FEATURES

● No other steam trap has all the advantages of Anderson Super-Silvertop—advantages that mean easier installation, greater accessibility, increased capacity and long, trouble-free service life.

The choice of elbow or straight-in-line connection is realized from the two inlet connections—one at the top, one at the side (a pipe plug closes the unused inlet). This is honest-to-goodness simplified piping. No extra fittings to buy and install, no piping all around the trap, a saving of as much as one hour per trap whether it's elbow or straight through. Besides, since all piping is in the head (see illustration above) trap can be inspected without disturbing pipe connections.

Inverted Bucket is guided, controlled to vertical motion only and this permits a larger bucket. Also, since lever arm is fastened beyond the center of the bucket, lever is longer. Larger bucket and longer lever open a larger valve for increased condensate capacity for any given size of trap body.

In Anderson Super-Silvertops, all passages are drilled, not cored—this insures full-sized passages in every trap—smooth passages that are slow to clog and quick to clean. Gasket is a full gasket—no split gasket that might become a source of steam leaks. These facts and guided bucket, together with 54 years of steam trap manufacturing experience, are the reasons for long, trouble-free service life.

Get all the facts about Super-Silvertop—write today for your free copy of the book—"How To Choose A Steam Trap"—it will help you.

1 CHOICE OF ELBOW OR STRAIGHT-IN-LINE CONNECTIONS

2 GUIDED INVERTED BUCKET

3 FULL-SIZED DRILLED PASSAGES

4 NO SPLIT GASKET

THE V. D. ANDERSON COMPANY
1939 West 96th Street • Cleveland, Ohio

Super-Silvertop STEAM TRAPS

A Plus Service For Engineers

Backing up their regular advertisements in POWER PLANT ENGINEERING, many manufacturers have prepared special catalogs and bulletins describing in greater detail the construction, installation and operation of their equipment. This literature is up-to-the-minute and frequently contains engineering data not available elsewhere.

Should you desire a catalog or specific information regarding power plant equipment, we will gladly get it for you from the manufacturer. Let us know also if you are interested in any particular piece of equipment, such as a pump, compressor, motor, fan, superheater, and we will get useful data for you on the different makes. Just write our Reader Service Department.

Iowa Expansion

IOWA PUBLIC SERVICE Co. (a subsidiary of the Sioux City Gas & Elec. Co., Sioux City, Ia., R. F. Burkhart, chief engineer) is making changes and improvements in three plants.

At the steam plant at Idagrove, Iowa, a new 18,000 lb. per hr. Murray boiler fired by Detroit spreader type stoker is just about ready for service. This boiler will be operated at 165 lb., 366 deg. F., and replaces two old boilers in an existing building.

At Charles City, Iowa, a 50,000 lb. per hr. B. & W. boiler to be fired by Detroit spreader type stoker has been purchased and planned for installation early in 1942. Building changes are now being made. The boiler will operate at 500 lb. ga., 700 deg. F., will be fed by an Ingersoll-Rand 6-stage, 150 g.p.m motor driven boiler feed pump.

At Lafayette St. Station, Waterloo, Iowa, a 120,000 lb. per hr. Edge Moor boiler designed to operate at 500 lb., 800 deg. F. will be installed in 1942 in space already available in the plant. This boiler wil be fired by Detroit spreader stoker with continuous ash discharge and will be equipped with a Prat-Daniel fly ash collector. Flue gas will be discharged to a 273 ft. reinforced concrete stack, 10 ft. I.D. at the top. Two 6-stage, 325 g.p.m. Ingersoll-Rand boiler feed pumps will be provided, one turbine, the other motor, driven.

TVA to Operate Aluminum Co. Plants

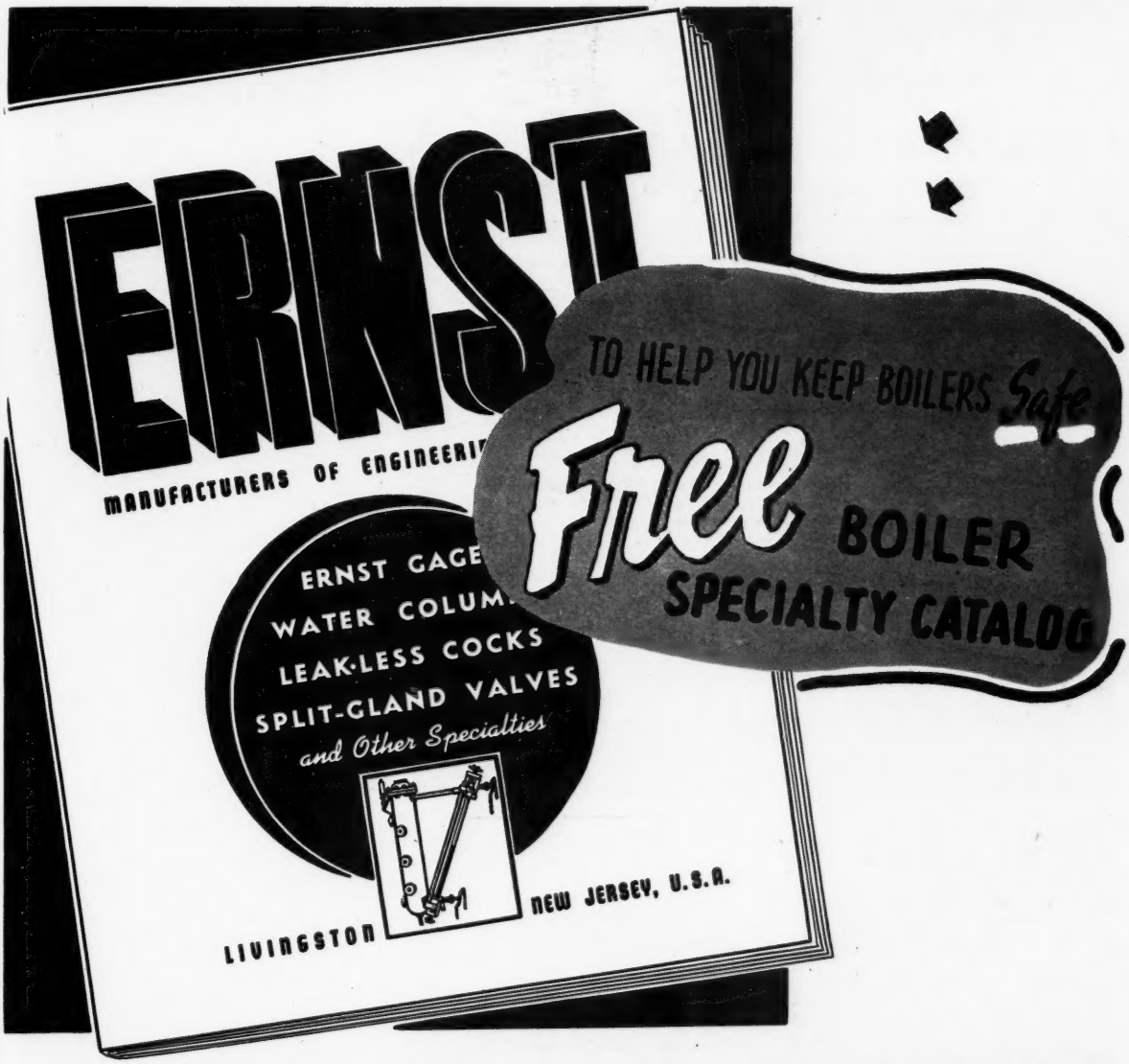
UNDER AN AGREEMENT signed the middle of August, the Tennessee Valley Authority is to operate the five-dam hydroelectric system of the Aluminum Co. of America. TVA will not assume ownership but will direct and control the operation in conjunction with its own system so as to obtain the maximum usefulness of the water in the Tennessee River watershed.

The Aluminum Company hydroelectric projects on the Little Tennessee River consist of Cheoah, Calderwood and Santeetlah, built a number of years ago primarily to supply power to what is now the world's largest aluminum plant at Alcoa. Two additional dams, Nantahala and Glenville, are nearing completion.

In addition to these five, the company has owned for some 30 yr. the so-called Fontana dam site. This dam site will be taken over by TVA and, provided Congress supplies the necessary funds, TVA plans to construct a 450 ft. dam which would require almost three times as much concrete as Norris Dam.

This dam would provide approximately 1,500,000 acre-feet of flood storage and add approximately 200,000 kw. of capacity to the TVA system. The dam would cost an estimated $50,000,000 and has already received the approval of O.P.M. as a defense necessity.

It is expected that the dam could be in partial use by 1943 so as to substantiate increase TVA and Alcoa power capacity in the downstream power plants. It is estimated that the structure can be completed in from 30 to 36 mo. The TVA system now totals 1,050,000-kw. This is scheduled to be increased to nearly 1,600,000-kw. by the end of 1942 and the Fontana project would bring the total capacity to 2,200,000 in 1944.



You'll find this new Ernst Catalog mighty useful in avoiding shutdowns by keeping boilers in service under all conditions. It pictures and describes the applications of Ernst Adjustable Water Gages, Water Columns, Try Cocks, and Safety Guards so essential for safe operation and maintenance of boilers.

Study the pages of this catalog carefully for your requirements. If you need help in determining the proper type of equipment for your plant, we will gladly send a representative.

Write for your copy of this new book. It's free while the supply lasts.

ERNST WATER COLUMN & GAGE CO., LIVINGSTON, N. J.

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Ernst Water Column & Gage Co.
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SAVE CHROMIUM
HELP NATIONAL DEFENSE

You can save chromium for defense and save money in your own plant by using our Chrom Glucosate. You are wasting chromium, badly needed in our National Defense program, when you use it for corrosion control instead of chrom glucosate.

Look at this table of comparison. It tells a commanding story.

COMPARATIVE CHROMIUM CONSUMPTION USING GLUCOSATES AS COMPARED TO CHROMATES

Amt. in form of Glucosate	Amt. as dichromate	Application	Saving
SODIUM BICHROMATE			
17 pounds	100 pounds	Calcium Brine	83 lbs.
17 pounds	200 pounds	Salt Brine	183 lbs.
34 pounds	500 pounds	Cooling Water	466 lbs.
CHROMIC ACID			
3 pounds	66 pounds	Calcium Brine	63 lbs.
3 pounds	132 pounds	Salt Brine	129 lbs.
10 pounds	330 pounds	Cooling Water	320 lbs.

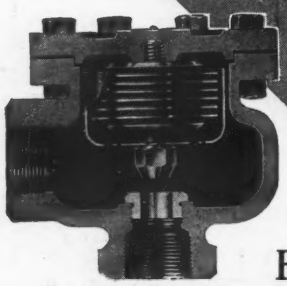
Furthermore, there are other glucosates that eliminate the need of chromium. Let us send you the whole story.

Help us to stop the waste of chromium ore. Switch to Chrom Glucosate at once and tell your business acquaintances the story of Chrom Glucosate too.

WATER CONSULTANTS

D. W. HAERING & CO., INC.
GENERAL OFFICES: 205 West Wacker Drive
CHICAGO, ILLINOIS

Avoid FREEZE-UPS
Install
NICHOLSON
Industrial Steam Traps



Also NICHOLSON—
Welded Floats, Piston and Weight Operated Traps, Flexible Couplings, Steam Eliminators and Separators, Compressed Air Traps, Expanding Mandrels, Arbor Presses

HERE is a trap that completely drains itself. It is non-freezing and non-airbinding, requires no adjustment. Ideal for outside installations or in buildings where steam is off at times during the winter.

Nicholson Traps are available in Bronze, Cast Iron and Cast Steel construction in sizes ¼ to 2 in. Good for pressures up to 300 lb. Specify Nicholsons for improved drainage of Unit Heaters, Pipe Coils, Water Heaters, etc. Write for new Steam Trap Catalog No. 240.

W. H. NICHOLSON & COMPANY
160 OREGON ST. WILKES-BARRE, PA.

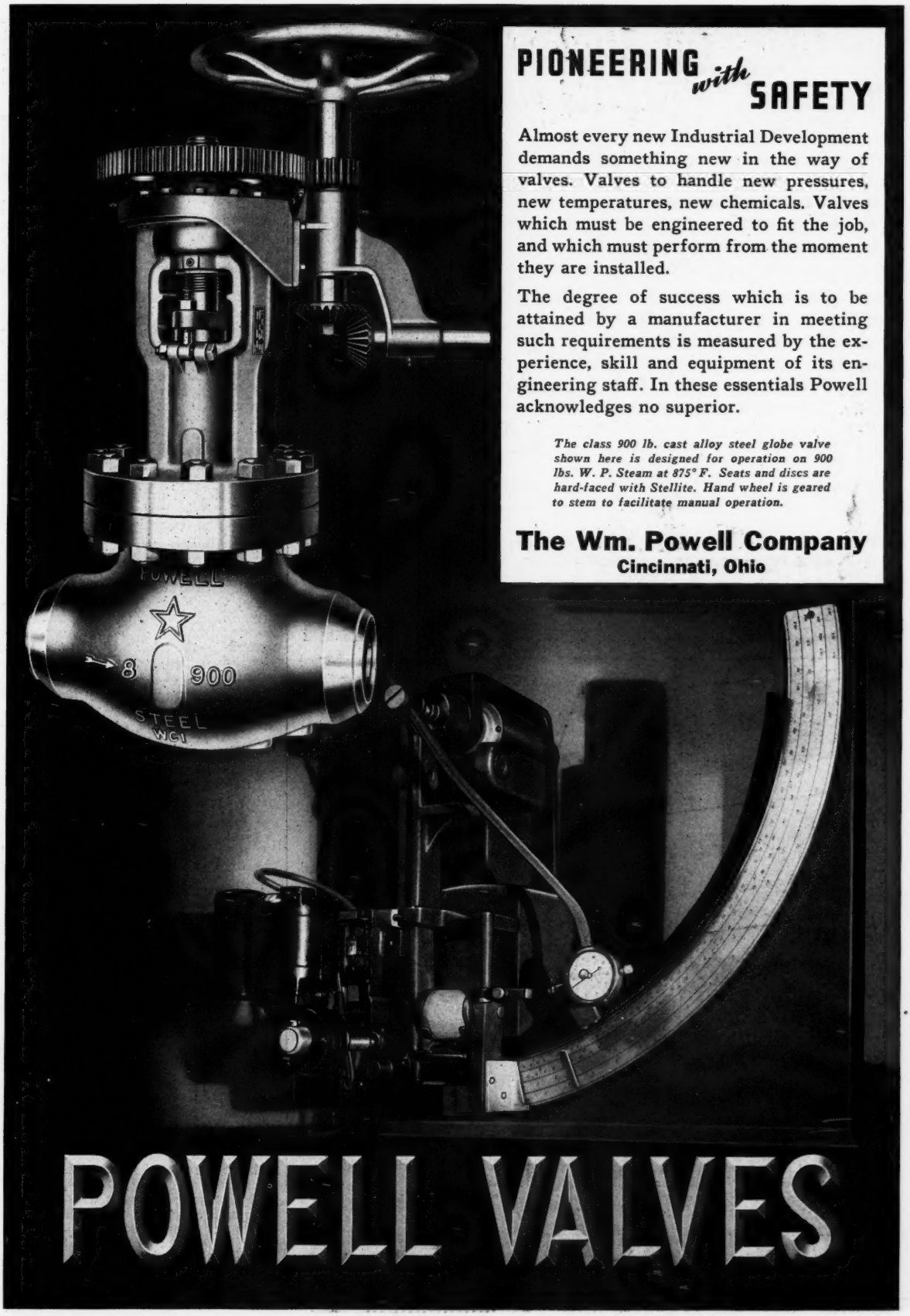
New Engineering Books

Electric Circuits. By Members of the Staff of The Electrical Engineering Department, Massachusetts Institute of Technology. First edition. 782 pages, 517 illustrations, 6 by 9 in. Cloth. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y., 1940. Price $7.50.

The staff of the Department of Electrical Engineering at the Massachusetts Institute of Technology has for some years been engaged in an extensive program of revising as a unit substantially its entire presentation of basic technological principles in electrical engineering. This volume on electric circuits is the first of a projected series covering this revised presentation. As pointed out by Karl Compton in the preface the decision to undertake so comprehensive a plan rather than to add here and patch there came from the belief that the Department's large staff with its varied interests in teaching and related research, could effect a new synthesis of educational material in this field of electrical engineering and evolve a set of textbooks with a breadth of view not easily approached by an author working individually. This first volume does ample justice to this plan. It is the most complete and unified treatment of fundamental principles of electric circuits we have ever seen. Aside from its unique value as a textbook to students it should be of equal value and interest to electrical engineers for reference and study.

The book is principally devoted to a thorough treatment of linear circuits. In the presentation of this subject, emphasis is given to the relation of circuit theory to field theory and the general scope and limitations of circuit theory are indicated. Graphical and analytical methods for determining values of circuit parameters are developed. The study of circuits as such includes the steady state and transient behavior, first of simple circuits, then of more complex networks, with suddenly impressed constant or sinusoidal forces. After the general development of the network theory, attention is given to the study of complex function loci, polyphase systems including the method of symmetrical components, and to the study of equivalent electric-circuit representation of electromechanically coupled systems.

Of particular general interest is the introduction which is a survey of the electrical art and its historical and present day significance. In itself this introduction should furnish inspiration for further study of the technical aspects of the subject. The fact that this book and the volumes which are in preparation are the result of collaborative endeavor involving substantially the entire staff of the Massachusetts Institute's Department of Electrical Engineer is in itself ample reason for its excellence.



PIONEERING *with* SAFETY

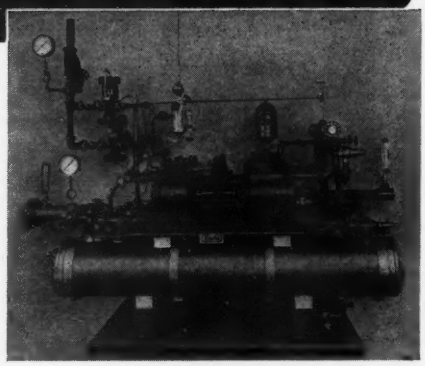
Almost every new Industrial Development demands something new in the way of valves. Valves to handle new pressures, new temperatures, new chemicals. Valves which must be engineered to fit the job, and which must perform from the moment they are installed.

The degree of success which is to be attained by a manufacturer in meeting such requirements is measured by the experience, skill and equipment of its engineering staff. In these essentials Powell acknowledges no superior.

The class 900 lb. cast alloy steel globe valve shown here is designed for operation on 900 lbs. W. P. Steam at 875° F. Seats and discs are hard-faced with Stellite. Hand wheel is geared to stem to facilitate manual operation.

The Wm. Powell Company
Cincinnati, Ohio

There's no time NOW for POWER PLANT FAILURE



POWER plant failure is costly at any time — TODAY, it must not happen.

In oil burning plants, ENCO Fuel Oil Pumping and Heating Systems not only deliver oil to the burners safely, and at the proper temperature and pressure, but provide DOUBLE PROTECTION against failure, as well.

Duplicate pumps and heaters are used, each of full capacity. These are interconnected so that operation is obtained with any combination of pump and heater. Screw or rotary pumps, with motor or turbine drive may be furnished, whichever are best suited to the installation.

The finished product is a complete unit, ready to place on foundation and to receive pipe connections.

Write for Instruction Book OBI-38 on the care and operation of Oil Burner Installations; also Bulletin OB-37 describing ENCO OIL BURNING EQUIPMENT.

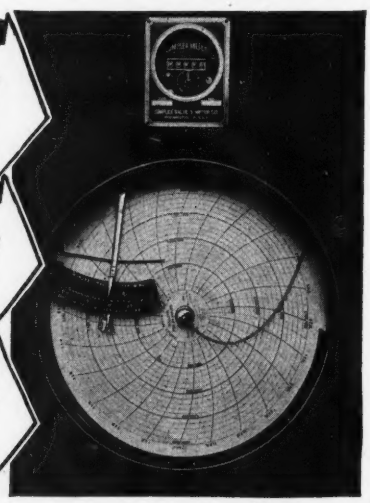
THE ENGINEER COMPANY

75 WEST STREET Enco NEW YORK, N.Y.

It TOTALIZES

It INDICATES

It RECORDS



THIS view of the streamlined "business head" of a Simplex Type MS Meter shows how it gives plant engineers an accurate 3-way picture of important water flow conditions:

1. By a uniformly graduated Indicating Scale;
2. Direct reading on a graduated Recording Chart;
3. By easily-seen Totalizer Dial at top.

Simplex Meters can be used in any size of main to totalize the flow of Boiler Feed, Condensate, Steam, Air, Gases and Corrosive Liquors. They are extremely accurate over wide ranges, moderate in price, easy to maintain. Write for descriptive Bulletin No. 52.

SIMPLEX VALVE & METER CO., 6790 Upland Ave., Philadelphia, Pa.

SIMPLEX METERS

Electromagnetic Devices. By Herbert C. Roters. First edition, 561 pages, 267 illustrations, 6 by 9 in. Cloth. John Wiley and Sons, Inc., 440 Fourth Ave., New York, N. Y., 1941. Price $6.00.

To those who occasionally have had to design electromagnetic devices of one type or another this book will be a welcome addition to the electrical literature. While much has been written on the design of electromagnets, the material is scattered and often difficult of access.

This book is intended primarily as a textbook for graduate students in electrical engineering and as a reference book for engineers concerned with the development or design of new electromagnetic devices. A familiar knowledge of the subject matter generally taught in undergraduate courses in electrical engineering is assumed.

The book is divided into two parts: the first eight chapters in which the fundamental background theory and methods applicable to all types of magnetic circuits and non-rotary electromagnetic devices are developed, and the last six chapters in which these principles are applied to the solution of a variety of problems. These solutions have been developed in general terms, and each is followed by the detailed numerical solution for a particular set of data.

Mr. Roters who is now Director of Research for the Fairchild Aviation Corp. was formerly Assistant Professor of Electrical Engineering at Stevens Institute of Technology. The material in the book has been presented to graduate students at Stevens Institute for several years.

A large amount of quantitative data is presented, many of which are original and have been obtained by painstaking laboratory work done at Stevens by graduate and undergraduate students working on those projects and also by the author. Many of the original problems and methods used in the last chapters of the book were developed in the course of the author's experience as a consulting engineer in the field. The book is a most worth while contribution to the field of electrical engineering.

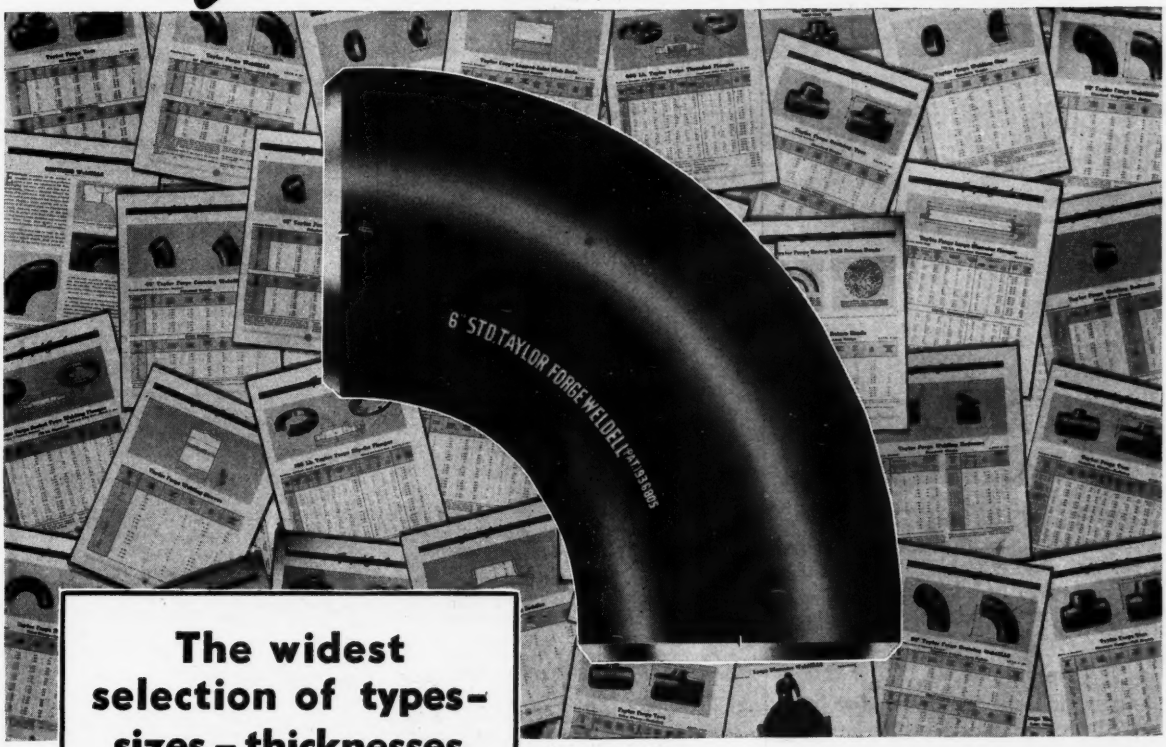
Lessons in Arc Welding. Second edition. 176 pages, 170 illustrations, 6 by 9 in. Semi-flexible simulated leather. Published by The Lincoln Electric Co., Cleveland, Ohio, 1941. Price 50 cents postpaid in U. S. A., 75 cents elsewhere.

This book makes available to industry and to engineering and trade schools and colleges the accumulated welding instruction information from the Lincoln Welding School which has been in continuous operation for 24 years.

Helpful to beginners learning to arc weld, also to experienced welders desiring its comprehensive practical information, and to supervisors, foremen and instructors the book is a ready reference on arc welding and a guide to its proper application.

In a series of 60 lessons, it presents in a concise manner, fundamental facts of welding, knowledge of which will enable the welder to utilize the process successfully and economically. Be-

You can always get what the job calls for in the WeldELL *line!*



The widest selection of types–sizes–thicknesses

ONE of the major advantages in using Taylor Forge WeldELLS and other Taylor Forge Welding Fittings is that in this one broad line is included practically every type, size, thickness and material that is ever required on any pipe welding job.

Naturally not all of the many types of Taylor Forge Welding Fittings are as widely used as WeldELLS. There are bound to be some "slow movers" in such a big line, and the small demand for such fittings, with no corresponding reduction in tooling and other production costs, sometimes makes them unprofitable to us.

But we couldn't follow our basic business principle of providing *maximum utility, convenience and economy,* and be satisfied with a "short line" The needs of our customers are too important to us. That's why you'll find Taylor Forge making a more complete line of Welding Fittings than any other manufacturer.

Just another example of the extra value Taylor Forge provides at no extra cost to the user . . . for WeldELLS and other Taylor Forge Fittings for Pipe Welding cost no more than other makes.

• To learn just how complete the Taylor Forge line really is get Catalog 401. There's a lot of other useful information in this book, too. Write for your copy today.

OTHER EXTRA VALUE FEATURES

In addition to the features described opposite, WeldELLS have the following advantages which are combined in no other welding fitting:

1. Seamless—greater strength and uniformity.

2. Tangents—keep weld away from zone of highest stress—simplify lining up.

3. Precision quarter-marked ends—simplify layout and help insure accuracy.

4. Permanent and complete identification marking*—saves time and eliminates errors in shop and field.

5. Selective reinforcement—provides uniform strength.

6. Wall Thickness never less than specification minimum—assures full strength and long life.

7. Machine tool beveled ends—provides best welding surface and accurate bevel and land.

*Since the marking is pressed into the metal before forming, and since the manufacture of the fittings is carried out at a forging temperature, each in effect receives a heat treatment after the operation. The indentations have no sharp corners or edges and the marking has no effect on the strength of the fitting.

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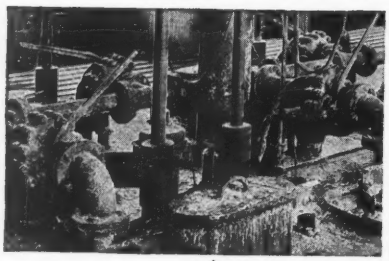

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ginning with an introduction giving preliminary instruction to the welder, including suggestions for making and following a definite plan for learning the fundamental principles of arc welding, and for practicing continually, examining welds, criticizing work, the book covers all aspects of practical arc welding in a manner that is simple to understand. A 25 page question and answer section enables the student to check his knowledge. The book may be purchased directly from The Lincoln Electric Co. or through any of its branch plants, dealers or representatives, or through recognized book dealers.

Testing Electrical Installations and Machines. By J. R. Stuart. First edition. 200 pages, 118 illustrations, 5 by 7¼ in. Cloth. Chemical Publishing Co., Inc., 148 Lafayette St., New York, N. Y., 1941. Price $2.50.

This book forms a useful reference work on present day practice in all kinds of commercial electrical testing as distinct from purely laboratory test work. It covers insulation and continuity tests for wiring installations, factory testing of transformers and motors, and the localizing of faults on distribution cables. The treatment is directed towards conveying practical information as to the exact methods to be employed in carrying out these tests. It is intended for contractors, wiremen and factory electricians.

Transformers. By Eric E. Wild. First edition. 132 pages, illustrated. 6 by 8½ in. Cloth. Chemical Publishing Co., Inc. 148 Lafayette St., New York, N. Y., 1940.

A concise account of the theory design and operation of transformers. Design is a very wide subject but an attempt has been made to discuss the underlying principles and to develop some of the leading formulas with indications of the values of the empirical constants likely to be used. There are chapters on testing and on transformers for special purposes. The book contains many diagrams and a considerable number of worked and unworked examples.

Air and Gas Compression. By Thomas T. Gill. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York City. Size 6 by 9 in., 177 pp., cloth bound. Price $3.00.

Treatment of air and gas compression has fallen into a more or less stereotyped form based primarily on theoretical considerations occasionally modified by more or less arbitrary correction factors. Because of this there has been a scarcity of good books on this subject of recent years, a scarcity which is, however, well covered by this small but important volume.

In the preface the author says, "Recent researches in the properties of gases, especially in regard to compressibility, critical data, and specific heats, have prompted me to attempt to apply some of the results attained to the solution of the problems of air and gas compression." This he has done very nicely in a practical engineers book trimmed down to bare essentials.

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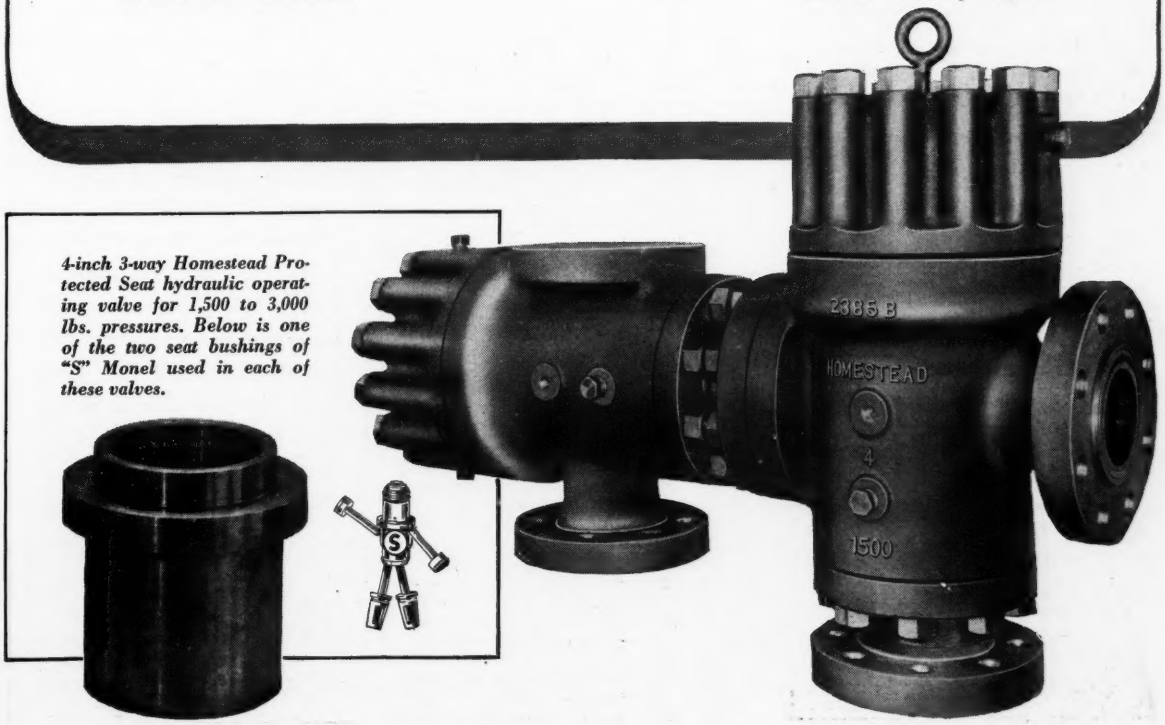

4-inch 3-way Homestead Protected Seat hydraulic operating valve for 1,500 to 3,000 lbs. pressures. Below is one of the two seat bushings of "S" Monel used in each of these valves.

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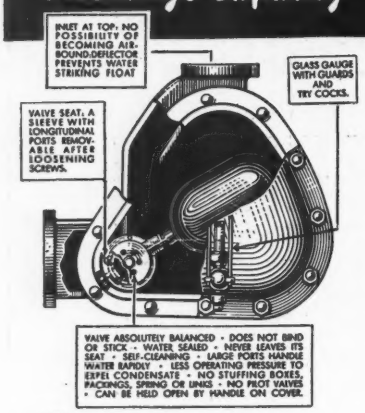
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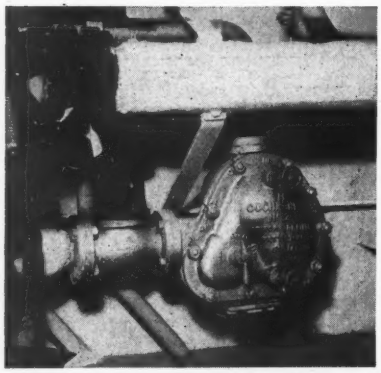

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who retain a basic working knowledge of compression, as covered in a typical thermodynamics text, will find the author's brief review of fundamentals and working formulas adequate. Others will find a more extensive review of these fundamentals helpful.

Beyond this brief review of fundamental gas laws and gas properties (including refrigerants) the book covers: single and multistage compressors; compressor capacity; horsepower; volumetric efficiency and clearance; use of the indicator; barometric pressure and altitude effects; the exponent of compression and deviation from ideal gas laws; vacuum pumps; compressors and compression plants. Because much of the practical application of high pressure compressors, has been in the petroleum industry there are also chapters on gas lift and pressure maintenance flow of gas in pipe lines and gas measurement.

Perhaps the most valuable part of the book are some 28 alignment charts for the solution of practically any gas compression, flow or metering problem, with their use explained and in many cases illustrated by practical examples.

Power Transformers. By J. Rosslyn. First Edition. 232 pages, 107 illustrations, 5½ by 8½ in. Cloth. Chemical Publishing Co., Inc., 148 Lafayette St., New York, N. Y., 1941. Price $2.50.

A handy reference work for engineers responsible for the installation, operation and maintenance of power transformers. It describes methods of connection and protective devices such as the Merz Price system of protection and also discusses the testing and purification of transformer oils. Though written in Great Britain the fundamental material presented is equally valuable in America. The chapter headings are as follows: I. Principles and Construction. II. Transformer Connections. III. Tap Changing Equipment. IV. Transformer Installation and Testing. V. Transformer Protection. VI. Oil Testing and Maintenance. VII. Transformer Faults and Failures.

Storage Batteries. By George Wood Vinal. Third Revised Edition. 664 pages, 170 illustrations, 6 by 9 in. Cloth. John Wiley and Sons, Inc., 440 Fourth Ave., New York, N. Y., 1940. Price $5.00.

This is a general treatise on the physics and chemistry of storage batteries and their engineering applications. Previous editions of this book were published in 1924 and 1930. This third edition improves on the two previous editions and makes full use of the new and more accurate data that have become available during recent years. Batteries have found new uses, manufacturing methods have been modified, theoretical studies have shown remarkable agreement between thermo and electrochemical calculations. All these things as well as many others are discussed in this new edition.

The author is Chief of the Section of Electrochemistry at the National Bureau of Standards and his obvious familiarity with the subject has enabled

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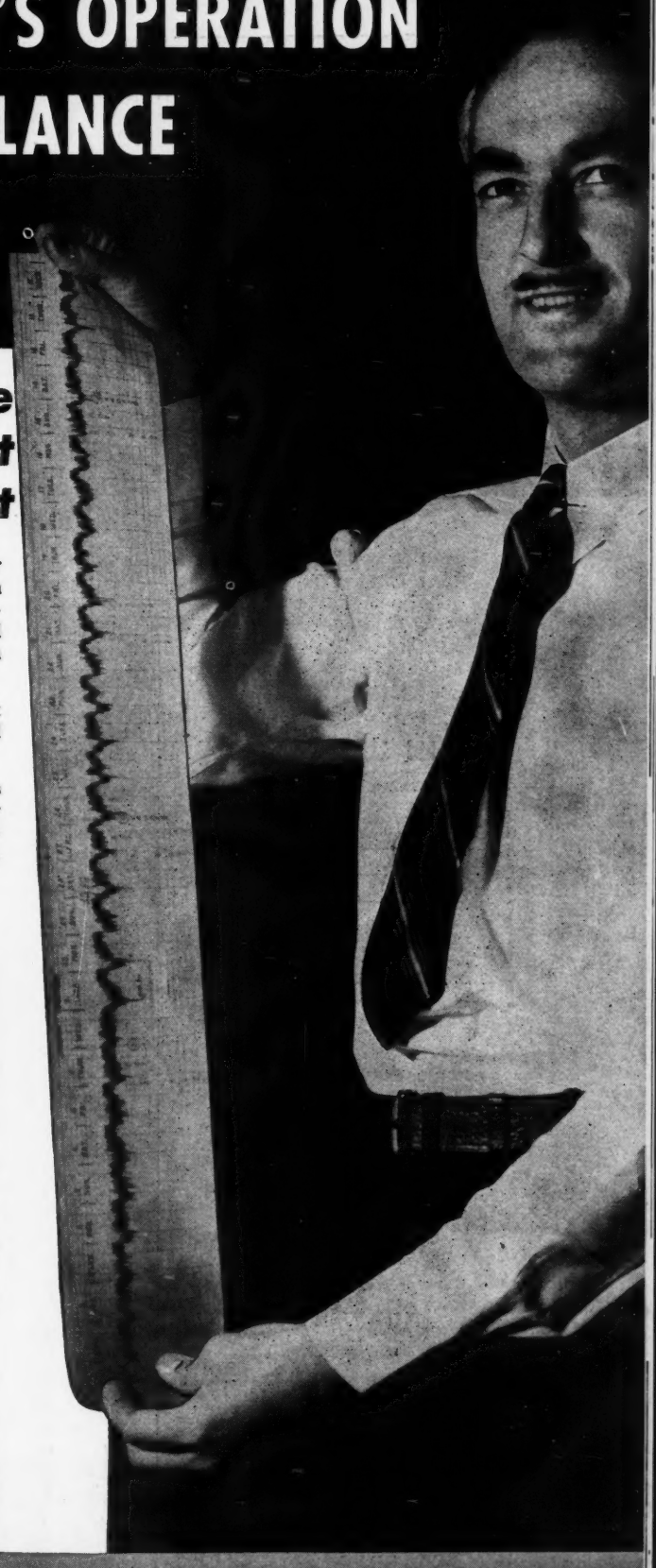

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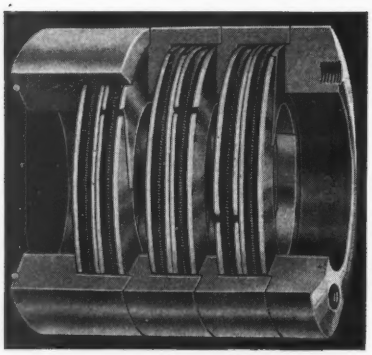

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him to produce a volume that is of value to both the theoretical and the practical man. A large part of the book can easily be understood by those lacking a technical training. For the more advanced worker there are included equations, charts, graphs, tables, etc. Not the least important is a good index.

Wiring Circuits for Lighting, Power and Industrial Control. By J. R. Stuart. First edition. 208 pages, 202 illustrations, 5 by 7¼ in. Cloth. Chemical Publishing Co., Inc., 148 Lafayette St., New York, N. Y., 1941. Price $2.50.

A handy little volume containing an interesting collection of circuit diagrams grouped under the following main headings: Lighting circuits, Motor starters, Transformers, Rotating converters, Battery chargers, Photoelectric controls, Time switches, Special purpose circuits, Miscellaneous circuits. It is intended for installation engineers, contractors and factory electricians. Each diagram is carefully explained so that readers will have no difficulty in understanding the operation of the various circuits included in the book.

Practical Air Conditioning. By Adolph J. Rummel and Lewis O. Vogelsang. First edition. 282 pages, 61 illustrations, 5½ by 8½ in. Cloth. John Wiley and Sons, Inc., 440 Fourth Ave., New York, N. Y., 1941. Price $2.75.

Air conditioning to most people means a cold interior when it is warm or hot outside. In its broad aspects, however, air conditioning covers much more than mere cooling, though that remains a primary and essential branch of the art. Air conditioning involves cooling, heating, humidity control and ventilation and in some cases ionization. It is therefore an involved and complex subject—not one which can be mastered by correspondence in ten easy lessons with a job guaranteed with the last payment.

This book is concerned with the practical aspects of air conditioning. It has been prepared to assist those now engaged or who wish to become engaged in the air conditioning industry. It is written in as simple and non-technical language as possible and will serve admirably as an introduction to a large number of very excellent books available for the more advanced student or engineer.

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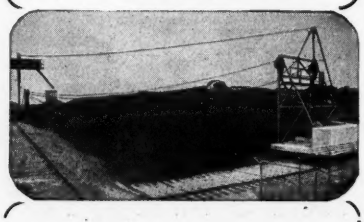

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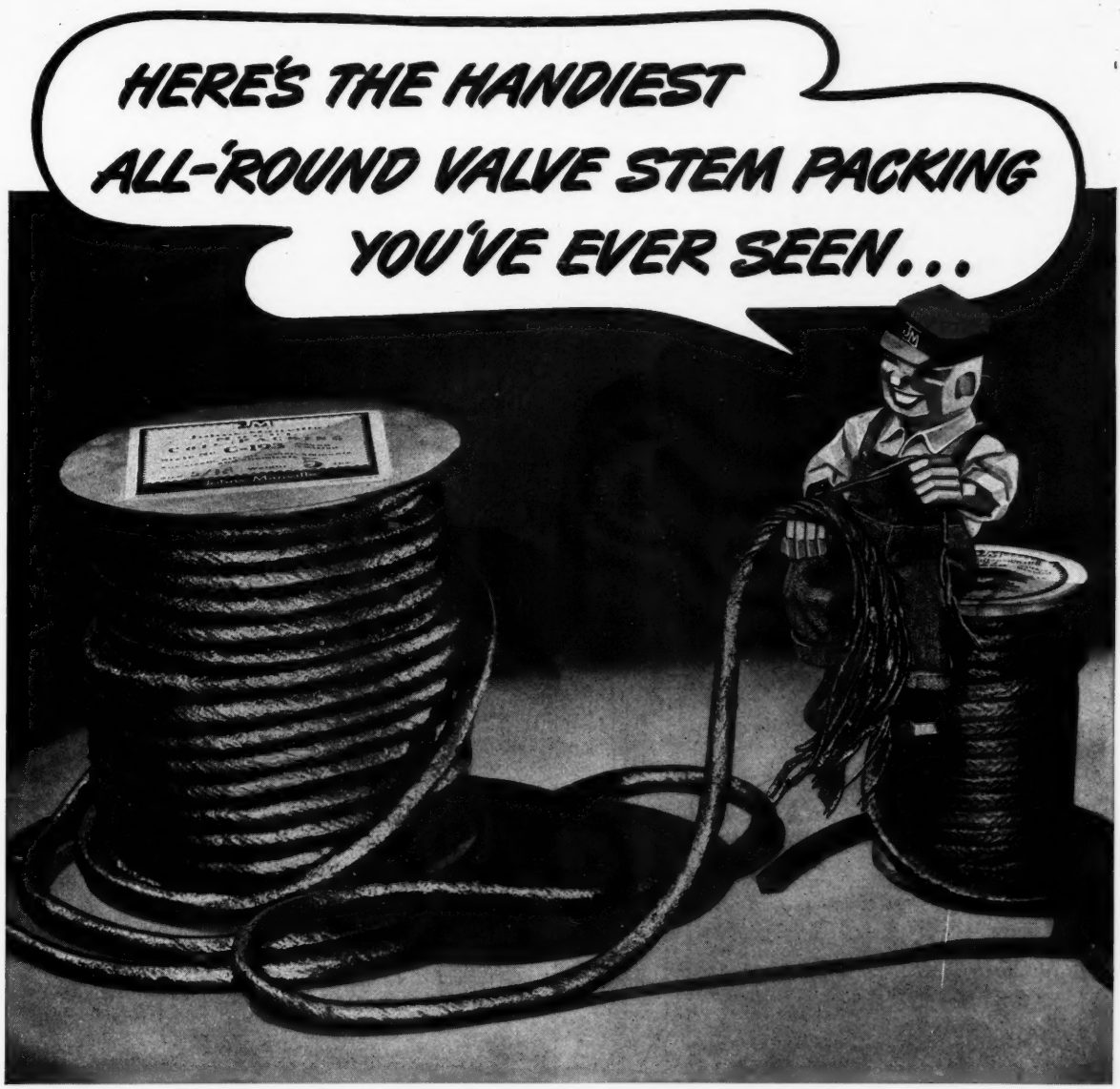

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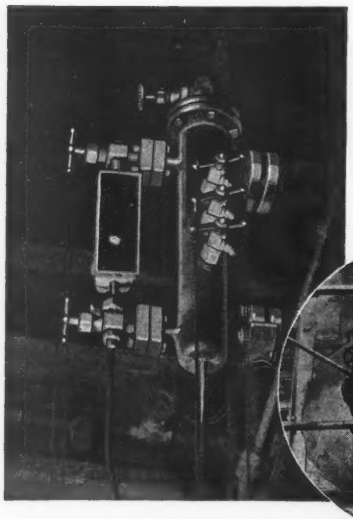

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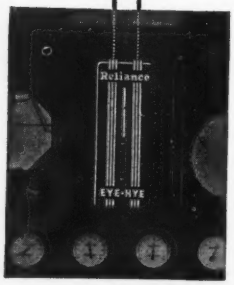

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Coupon for obtaining free literature listed here may be found on page 150, under the heading Helpful Bulletins.

Meters, Instruments and Controls

1 Control Instruments—Recently issued are monographs on boiler room instrumentation by William H. Pugsley, Manager of Engineering, cover No. 1, Control of Steam Pressure, No. 2, Combustion Control from Changes in Steam Pressure, Nos. 3, 4 and 5, Control with Underfeed, with Spreader Type and with Traveling Grate Stokers, Nos. 6 and 7, Control with Pulverized Fuel and with Oil Burners, No. 41-452, Control of CO_2, No. 41-472, Use of Draft Gages, No. 40-448, Relation of Combustion Control to Steam Costs. A convenient file folder keeps them in shape for ready reference. The Hays Corporation.

2 CO_2 Analyzer—How to Save 10 to 25 Per Cent of Your Steam Plant Fuel is the title of a new four page bulletin No. 40-452, devoted primarily to the reduction of fuel cost through proper CO_2 and the control of CO_2 through hand orsats or recording instruments. The Hays Corporation.

3 Meters—Brown Mechanical Flow and Liquid Level Meters are the subject of Catalog 2204, which gives in 16 pages vital facts on principles and details of meters, recording planimeter, chart timing and micrometer screw setting, with full descriptions and illustrations. The Brown Instrument Co.

4 pH Meters—Beckman pH meters are described in a bulletin entitled What Every Executive Should Know About pH. The major part of the 12-p. bulletin is devoted to a treatise on acidity and alkalinity and how they can be controlled. National Technical Laboratories.

5 Fuel Oil Meter—Fuel metering by positive displacement is explained in a 4-p. circular of the Vesta Meter. Fluid Meters, Inc.

6 Flame Protection—Bulletin 96-3 deals with Protectoglo systems, of flame, automatic relite and photo electrode types, for protection against failure of oil, powdered coal and gas flames. Equipment is described and illustrated, and the operating principles included. The Brown Instrument Co.

7 Pressure Controller—Bulletin No. 74-2 consisting of 8 pages, tells how, why, when and where Brown Furnace Pressure Controllers can be used to maintain constant furnace pressure automatically. Description of the control system is given with details of the Indicating Controller, Power Cylinder and Diaphragm Motor, with schematic diagram of hook-up for operation. The Brown Instrument Co.

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9 Feed Water Regulator—Folder of the Campbell regulator gives a description of construction advantages and list of users. Atlas Valve Co.

10 Thermocouples—Bulletin S2-3 is a new 32 pp. combined data book and catalog on thermocouples. In addition to the complete Wheelco line of thermocouples and thermocouple accessories, the book is a manual for thermocouple users with such data as temperature conversion tables, millivolt tables, pipe and wire sizes, etc. Wheelco Instrument Co.

Mechanical Power Transmission

11 Bearings—Catalog No. 5, a 16 pp. bulletin entitled Metaline Oilless Bronze Bearings, covers properties, types, applications and data for specifications. R. W. Rhoades Metaline Co., Inc.

12 Belt Vulcanizer—Catalog Section 2159 is a single sheet bulletin devoted to the Type RO portable vulcanizer for the speedy repair of minor cuts and gouges in a rubber belt and conveyor covering. The B. F. Goodrich Co.

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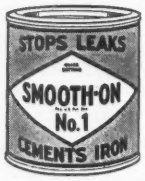

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stops leaks in boilers, heaters, pumps, valves, pipe lines, etc.; seals cracks in castings of apparatus and machinery; tightens loose fixtures and parts of equipment. Easy to apply. Becomes hard as iron. Sold in 7-oz., 1-lb., 5-lb. cans; 25-lb., 100-lb. kegs.

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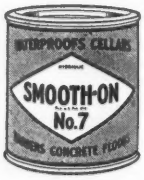

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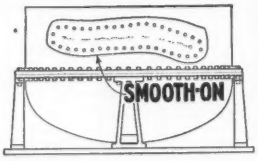

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13 V-Belts—More Power to You is the story of the new Super-7 V-belt as told in Bulletin B-6190. The booklet also explains how the Super-7 gives longer life; greater efficiency; gives a handy selection table and price lists for V-belts now available from stock. Allis-Chalmers Mfg. Co.

14 Gears—A new 52-p. catalog and data book No. 1874 on the P.I.V. Gear variable speed transmission has been issued. Units of ½ to 15 hp. capacity, with speed ratios of up to 6 to 1 are tabulated, illustrated, described. Speeds, torque ratings, dimensions, weights, and other data are given for all seven sizes. Link-Belt Co.

15 Bearings—A recently released catalog describes the properties and uses of self-lubricating bearings and furnishes details on the correct method of installation. Standard sizes are listed, with allowance on Selflube bearings for press fit into housing, and the allowance for running fit after installation. Keystone Carbon Co.

Electrical Equipment and Motors

16 Electrical Machinery—Principles and operation, are explained in a 48 pp. book, Catechism of Electrical Machinery, which covers electro-magnetic action in generators and motors and measuring instruments. Both d.c. and a.c. machinery are discussed, with photographs, diagrams and useful tables. Treatment, which is clear and simple, is in questions and answers form. Fairbanks, Morse & Co.

17 Bus Ducts—Bulletin 412 describes the LO-X duct and illustrates uses. Bull Dog Electric Products Co.

18 Conduit—Bulletin No. 381 illustrates and describes Therm-O-Tile underground steam conduit system, as permanent protection, support, and insulation of underground pipe lines—hot or cold. Monolithic sidewalk base, internal channel drain, arch and tile construction, pipe supports not carried by conduit, waterproof construction. H. W. Porter & Co.

19 Wire Data—Handy series of cards giving data and formulas on wire and cable, metric and decimal equivalents, motor wiring and hydraulic and horsepower formulas is issued as GES-2820 to 2824. General Electric Co.

20 Transformers—4 pp. Bulletin TU-34 describes a new type of transformer with protection against both surges and overloads. Wagner Electric Corp.

21 Alnico Magnet—This is the title of a booklet telling the story of a new damping magnet for watthour meters. It is of special interest as illustrating the thought and research involved in design and the care in manufacture, to secure improvements in metering equipment. The booklet is No. GES-2764. General Electric Co.

22 Resistances—Keystone negative temperature coefficient resistance material is described in a new 4 pp. bulletin recently issued. This material has a resistance which decreases as the temperature increases and is used to reduce or eliminate initial current surge in electrical equipment, to compensate for resistance changes due to temperature variations and to provide various degrees of time delay. Keystone Carbon Co.

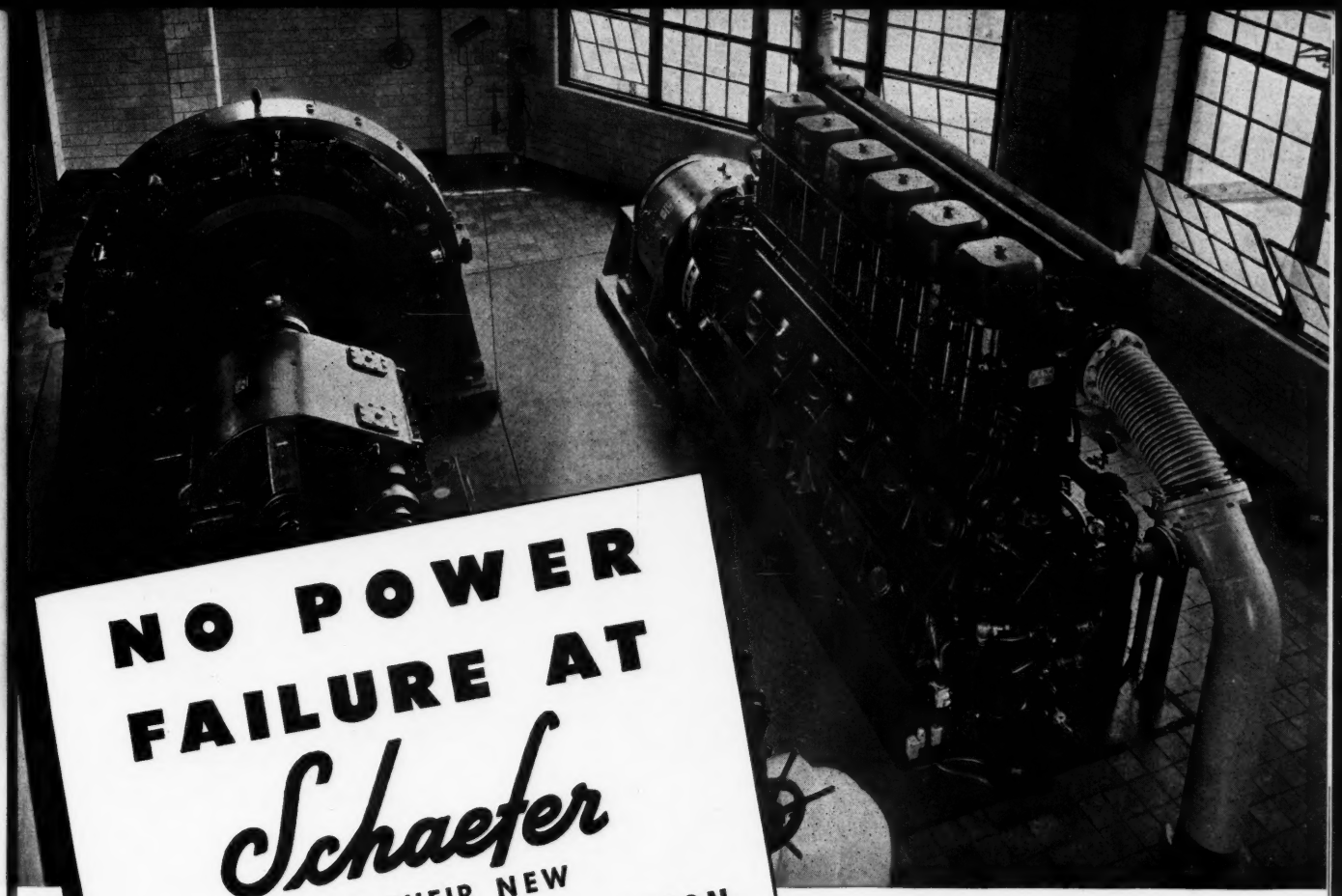
23 Safety—Issued recently is a series of bulletins on loss prevention in electrical equipment. Bulletin No. 15.15 deals with Fire Protection for Power Houses; No. 15.20 on Protecting Electric Generators; No. 15.21 on Safeguarding Switching Equipment; No. 15.30 on Safe Transformer Installations; No. 15.50 on Grouped Power Cables. Associated Factory Mutual Fire Ins. Co.

24 Plant Protection—Lighting for protection is discussed in GEA-3640 bulletin, which covers amount of light, distribution considering arrangement and area between buildings, types of lighting equipment and costs, connection on series and multiple circuits. General Electric Co.

25 Tool Motors—Enclosed construction, anchored windings, rigid base and frame arranged for a variety of mountings and ball bearings are features of the fractional-hp., ¼, ⅓, ½, ¾-hp. 3-phase motors at 1725 r.p.m. announced recently in bulletin GEA-3579. General Electric Co.

26 Motors—Recently issued is an 8 pp. Bulletin B6052-B which concisely describes the complete line of Lo-Maintenance Motors in ratings from ¾ to 75-hp. open, enclosed, and splash-proof types, a.c. and d.c. Allis-Chalmers Mfg. Co.

27 Motors—Motors For Driving Power House Auxiliaries is the title of a new 28-pp. bulletin, B-6107, recently issued. The bulletin describes the construction of Allis-Chalmers standard type motors, their characteristics and the application of different types to various auxiliary service. Allis-Chalmers Mfg. Co.



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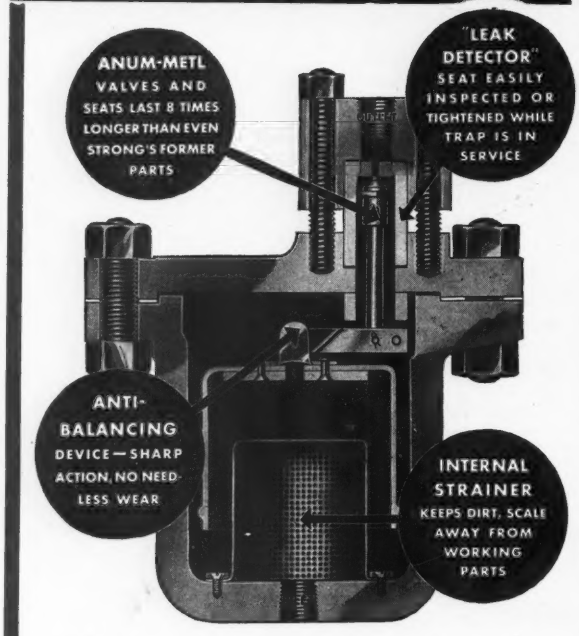
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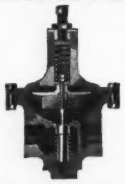

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STEAM SPECIALTIES

28 Motor Generator—Folder describing latest models of of M.G.C. motor generator sets, electroplating sets, and anodizing sets is issued by Motor Generator Corp.

Pumps and Compressors

29 Centrifugal Pumps—Bulletin No. 41-7050 is a new catalog describing the latest Byron Jackson SM process pumps for low head irrigation are illustrated and de- in both single and multi-stage, the impeller discharges through a volute, divided into two sections so as to give balanced forces and even loading of the shaft. Byron Jackson Co.

30 Pumps—A new line of short-coupled, base-mounted pumps for low head irrigation are illustrated and described in Bulletin 6720X. Fairbanks, Morse & Co.

31 Centrifugal Pumps—An 8 pp. book, B-6059, concisely describes and illustrates the wide range of pumps built by this company. Included in the book are pumps for handling capacities from 10 to 200,000 g.p.m. and for heads ranging from 10 to 4200 ft. Also single and double suction single stage pumps, double suction multi-stage pumps, open runner paper stock pumps, and axial flow pumps. Allis-Chalmers Mfg. Co.

32 Steam Pumps—Comprehensive, 4 pp. Bulletin No. 230-1 on Warren horizontal duplex piston pumps, "Realwear" Type includes specifications, sectional views, capacity tables, dimensions, ratings, etc. Warren Steam Pump Co., Inc.

33 Compressors—Catalog 194 describes and illustrates heavy-duty, horizontal, single-stage compressors for air or gas. Pennsylvania Pump & Compressor Co.

34 Compressors—Bulletin 192, a 26 pp. catalog, illustrates and describes horizontal, heavy-duty duplex compressors with details of construction, regulation, operation and performance. Pennsylvania Pump & Compressor Co.

Valves and Piping

35 Flexible Piping—New 12 pp. Bulletin 71 gives 1942 Standard Data on Penflex All Metal flexible pipes for Diesel installations for: fuel oil, starting air; lube oil; exhaust and air intakes, etc. Pennsylvania Flexible Metallic Tubing Co.

36 Valves—Catalog No. 95, 16 pp., covers the complete line of Henry packless and packed valves, strainers, dryers and other accessories for air conditioning and refrigeration. Many new lines and products are included, such as hand expansion valves, manifolds, relief valves, dehydrators and Dehydra-tector the latter used for determining the sufficiency of refrigerant in the system. Henry Valve Co.

37 Reducing Valves—A new 2 pp. folder, Form No. P-16-A, has recently been released giving details of application, construction and specifications of the Copes Type R-DSLH reducing valve built in sizes from 1 to 14 in. for pressures of from 125 to 1500 lb. Northern Equipment Co.

38 Relief Valves—Industrial pop safety and relief valves are described in Catalog 41V. Construction features are emphasized; instructions for the application, care and maintenance as well as repair and adjustment of Ashton pop safety valves are given; and full information regarding dimensions and capacities is included. Ashton Valve Co.

39 Expansion Joints—Packless expansion joints for all conditions, featuring the improved Expansion Joint Selector, which enables the engineer to select the proper expansion joint for almost every conceivable condition. Diesel exhaust connection is a new product with annular corrugations, to allow axial as well as lateral movement. Zallea Brothers & Johnson.

40 Expansion Joints—Gun-Pakt joints of steel construction and single or double ended, cylinder guided are described and illustrated, with data tables and dimensions in Bulletin EJ-1908. Yarnall-Waring Co.

41 Blow-off Valves—In revised Bulletin B421 are described Yarway valves for pressures up to 400 lb. with illustrations of various types and details of angle, straight-way, seatless and double tightening. Yarnall-Waring Co.

42 Valves—Catalog No. 201 is a new 12 pp. bulletin covering Edward steel valves for marine service. It also includes the latest Bureau of Marine Inspection and Navigation adjusted pressure-temperature tables for marine service. The Edward Valve & Mfg. Co., Inc.

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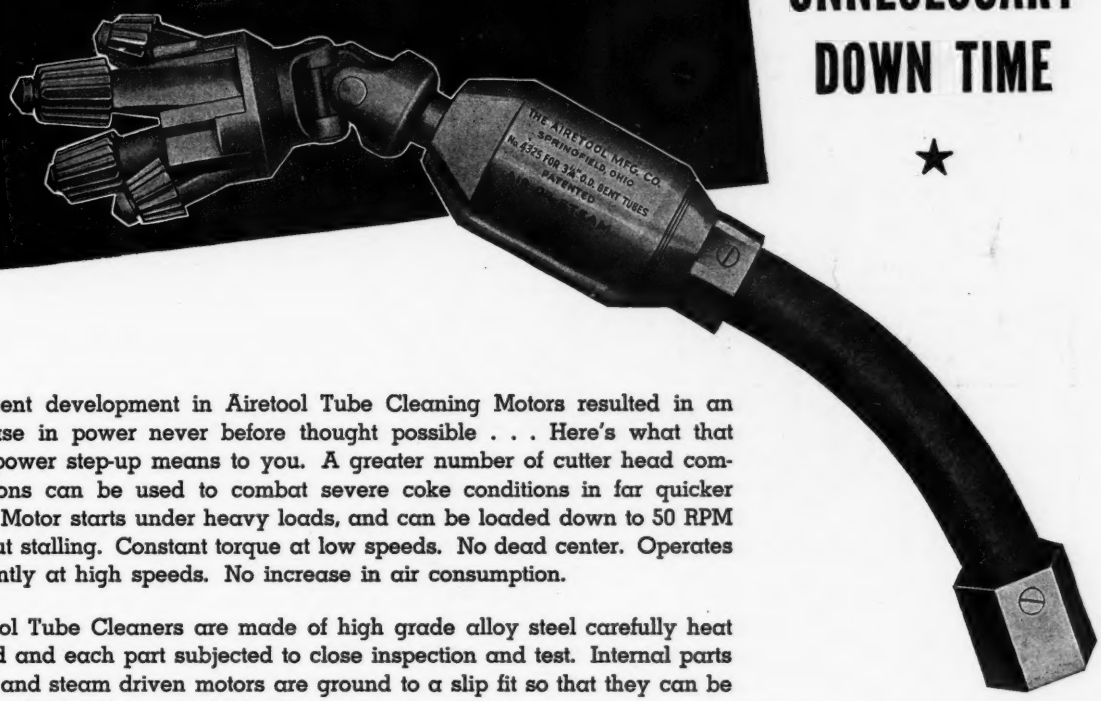

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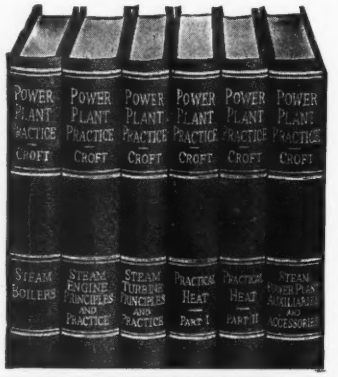

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43 Pipe Clamps—Here's How You Can Clamp Down on Bell-Joint Repair Costs is a new 12 pp. folder showing the application and advantages of Dresser bell-joint clamps made in standard sizes from 3 to 48 in. The folder also describes the Sealometer for registering the pressure exerted by the clamp gasket. S. R. Dresser Mfg. Co.

44 Pipe Bending—Cold bending equipment for iron, steel, copper and brass pipe and tubes is illustrated and described in a recently released circular. American Pipe Bending Machine Co., Inc.

Stokers, Refractories and Boiler Tubes

45 Stokers—Catalog 1204 is a 16 pp. bulletin in color of the F & E Series Seventy heavy duty industrial underfeed stokers made in four types with either electro-hydraulic or steam drive. The construction of the stoker is described, typical installation photographs, applications to different types of boilers shown. Flynn & Emrich Co.

46 Boiler Tubes—New, 24 pp. condensed catalog on B&W seamless steel boiler tubes, alloy tubes and pipe for refinery and process industries, stainless steel tubes and pipe, and seamless steel mechanical tubing, has recently been announced. Included are photographs and schematic line diagrams of the seamless tube manufacturing process. The Babcock & Wilcox Tube Co.

47 Refractory—Special refractory shapes cast in your own plant and ready for use within 24 hr. is the advantage given in a folder, Form RC-13A, on Firecrete and other castable refractories. These are described as suitable for door and other linings, burner rings, furnace bottoms, and special refractory shapes, in three types of Firecrete with temperature limits of 2200, 2400, and 2800 deg. F. and chrome castable for temperatures to 3200 deg. F. Johns-Manville.

48 Refractories—Application of Korundal, a super-duty corundum refractory, is discussed in a new 6 pp. folder. This is a new 90 per cent alumina brick with extremely high refractoriness, exceptional volume stability at high temperatures, high resistance to spalling and chemical action. Harbison-Walker Refractories Co.

Miscellaneous

49 Pressure Cylinders—Nopak cylinders for air and hydraulic service are described in a new 12-p. Bulletin 82 in color. These cylinders, applicable for pulling, pushing, hoisting and clamping operations, range in size from 1½ to 12 in. in diam. and are made in 8 different models, standard mounting brackets and clevises are included. Galland-Henning Mfg. Co.

50 Diesel Engines—Power for Industrial Plants is an 8 pp. booklet, Form 6904, showing Diesel engines and electric sets, to give the answer to various power situations, such as full time jobs, serving as auxiliary to other sources of power and acting as standby units. Caterpillar Tractor Co.

51 Oil Filters—Bulletin No. 20, an 8 pp. folder, describes two new permanent magnet FerroFilters, the PQ-5 and PQ-1 developed to meet the demand for capacities larger and smaller than the former models. These are applicable to the removal of fine metal particles in the lubricating system, coolants, hydraulic systems and process industries. S. G. Frantz Co., Inc.

52 Vibration Dampers—A new 4 pp. Bulletin BA 28 describes the application of the Korfund vibration control system with particular reference to the isolation of drop hammers. The Korfund Co., Inc.

53 Welders—Flexarc a.c. welders for every type of welding job ranging from light gauge sheet to sustained, heavy duty industrial fabrication are described in a new 8 pp. bulletin B-2285. Current ranges of these welders are from 20 to 625 amp. Westinghouse Elec. & Mfg. Co.

54 Arc-Welding Calculator—General Electric Arc Welderule operates similar to a slide rule, to give directly the length of arc welded joints obtainable per 100 lb. of electrode, also the pounds of weld metal deposited per 100 lb. of electrode. The information covers 11 different commonly used sizes and types of joints; also 22 different sizes and types of popular electrodes in both the 14- and 18-in. lengths. An additional feature are metal classifications as specified by the A. W. S. General Electric Co.

55 Welding—Supplies and equipment for electric welding, also the training course, given in the Hobart Trade School are illustrated and described in bulletins recently released. The Hobart Brothers Co.

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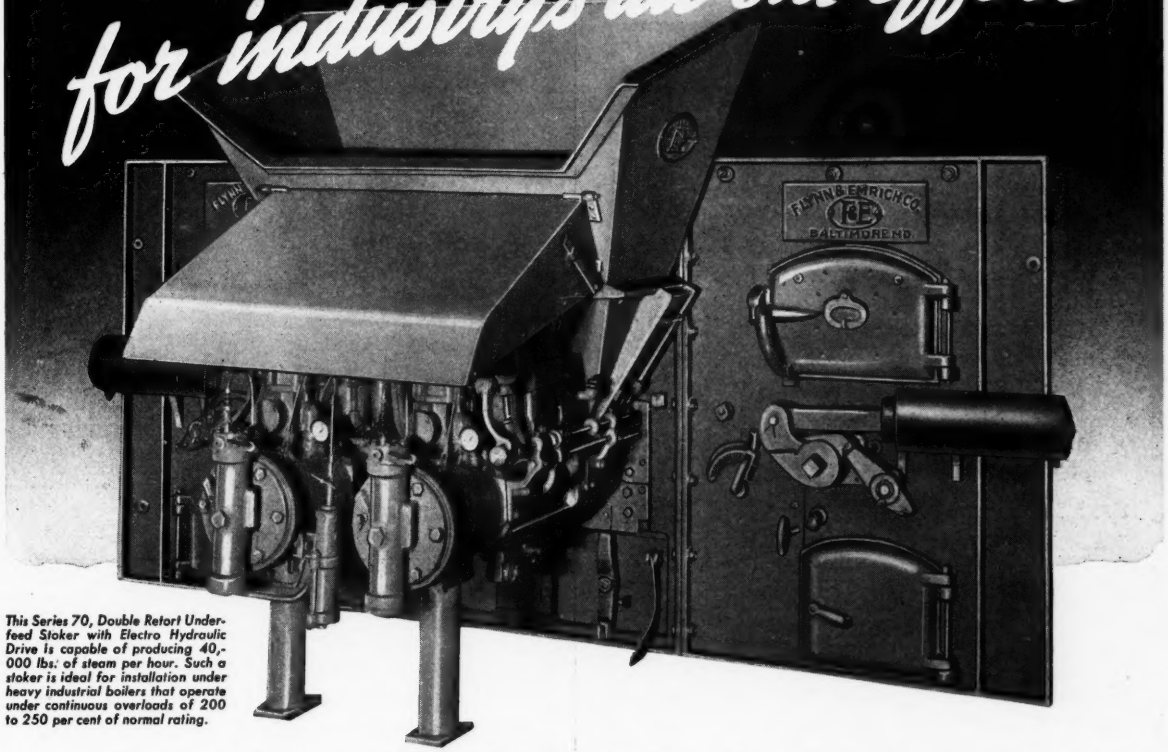

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56 Masonry Leaks—Stoppage of leaks in earth fills and in masonry and concrete structures by the use of Volclay is illustrated and described in a 12 pp. booklet listed as Data 229. American Colloid Co.

57 Vibrators—For controlling flow and feed of material in hoppers and chutes, the 48 pp. catalog, No. 416 illustrates and describes Syntron vibrators, conveyors, feeders, weighers, hammers. Syntron Co.

58 Contour Sawing—For vocational teachers and workmen on defense products, Contour Sawing Handbook gives illustrations and guide charts for removing metal by rapid precision methods and, in its 158 pp., gives comparison with results by other methods. Continental Machines, Inc.

59 Dust Collector—Bulletin 907 illustrates and describes Unit Type Collectors for attachment to individual grinders, planers, blast cleaning units, tumbling mills, with cloth screens in banks over wooden frames which are mounted in steel casings. Pangborn Corporation.

60 Boiler Specialties—The complete Ernst line of engineering specialties are shown in a new 28 pp. catalog No. 45 just issued. These include: water gages, vertical and inclined, round and flat glass, for low, medium and high pressures; water gage inserts; try cocks; gage glass illuminators; safety water columns and parts; gage glasses and gaskets; and gage glass safety guards. Ernst Water Column & Gage Co.

61 Springs—Details of five metals for spring construction for high and low temperatures, showing various types and uses of springs are given in a booklet on New Spring Alloys. International Nickel Co.

62 Lift Trucks—Facts About Towmotor is a 26 pp. bulletin on the seven models of Towmotor gasoline-powered lift trucks ranging in capacity from 2000 to 10,000 lb. It also includes a discussion of speeding production, increasing storage capacity and reducing handling costs. Towmotor Co.

63 Synthetic Rubber—An 8 p. catalog section on Ameripol D synthetic rubber, used in making mechanical rubber products, contains four tables that answer questions on Ameripol, such as: properties; hardness; tensile strength; elongation; weight; color; odor and taste; elasticity and permanent set; tear and abrasion resistance; and resistance to flexing, oils and solvents and heat. The B. F. Goodrich Co.

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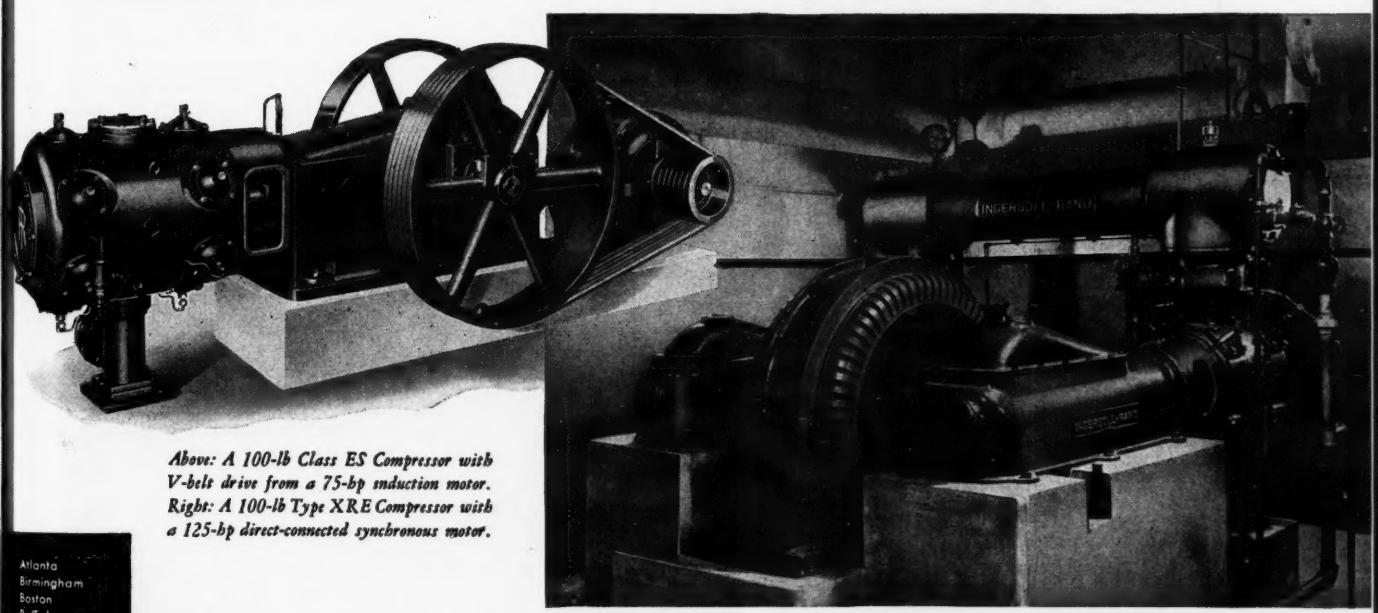

Above: A 100-lb Class ES Compressor with V-belts drive from a 75-hp induction motor. Right: A 100-lb Type XRE Compressor with a 125-hp direct-connected synchronous motor.

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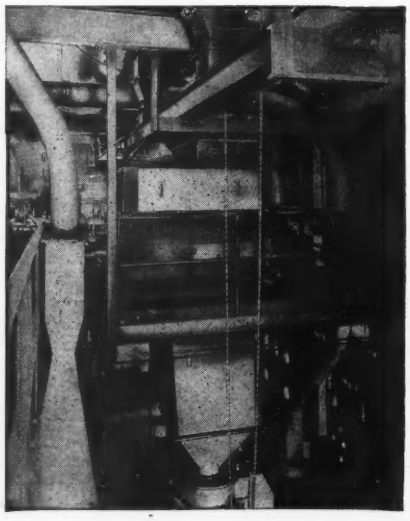

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Power Plant Construction News

Calif., San Diego—San Diego Gas & Electric Co., is completing plans and will begin superstructure soon for a new steam-electric power plant at foot of Sampson Street, to be known as the Silver Gate generating station. It will be 280 by 500 ft., equivalent in height to a six-story building. Cost is estimated at $3,500,000, with turbine-generators, high-pressure boilers and auxiliary equipment. Completion is scheduled in about 12 mo.

Calif., Santa Monica—Douglas Aircraft Co., Inc., 3000 Ocean Park Boulevard, manufacturer of airplanes and parts, plans installation of electric power equipment in connection with expansion in plant for production of bomber-type planes for Government. Cost estimated at $522,000. Fund in that amount will be furnished by Defense Plant Corporation, Washington, D. C., a Federal agency, for project.

Ga., Columbus—Eagle & Phoenix Mills, Front Avenue, plan installation of electric power equipment in five-story addition to cotton mill, 150 by 300 ft. Cost estimated close to $250,000. J. E. Sirrine & Co., Greenville, S. C., are consulting engineers. Work will begin soon.

Ill., East Alton—Western Cartridge Co., East Alton, manufacturer of cartridges, ammunition, etc., has approved plans for one-story power house at plant, for which superstructure will begin soon. Cost reported close to $70,000, with boiler unit and auxiliary equipment. Sargent & Lundy, Inc., 140 South Dearborn Street, Chicago, Ill., is consulting engineer.

Iowa, Dubuque—Interstate Power Co., 1000 Main Street, will soon begin construction of addition, 50 by 60 ft., to local steam-electric generating station, for expansion in steam division. A new boiler unit and auxiliary equipment will be installed. Sargent & Lundy, Inc., 140 South Dearborn Street, Chicago, Ill., is consulting engineer. No estimate of cost announced.

Iowa, Hawarden—City Council has plans maturing for extensions and improvements in municipal power plant, including installation of new 1000-kw. turbine-generator unit and auxiliary equipment. Cost estimated about $92,000. Buell & Winter, Insurance Exchange Building, Sioux City, Iowa, are consulting engineers.

Iowa, Murray—Town Council has plans under way for new municipal power plant, using Diesel engine-generating units and accessory equipment. Cost about $80,000. A bond issue in that amount has been arranged for project.

Kan., Crestline—Constructing Quartermaster, Seventh Corps Area, Omaha, Neb., plans steam power house at new synthetic ammonia plant on 1900-acre tract of land near Crestline. Also will build a power substation and install electric power equipment for works service. Plant will be operated for Government by Miners Chemical Works, Inc., care of Kenneth A. Spencer, Dwight Building, Kansas City, Mo. Entire project will cost about $20,000,000, and is scheduled for completion in 1942.

Md., Baltimore—Consolidated Gas, Electric Light & Power Co., Lexington Building, has authorized further expansion in new Riverside steam-electric generating station, where work is under way on installation of initial unit of 50,000-kw. rating, scheduled for completion in 1942. New unit will have a similar capacity, making a total of 100,000-kw. for station, and is reported to cost over $4,000,000, including high-pressure boiler and auxiliary equipment. Installation will follow work now in progress, noted.

Mich., Detroit—Johnson Creamery Co., 3300 Caniff Street, plans boiler house and compressor room at new creamery plant, 75 by 320 ft., on Mount Elliott Boulevard, near Luce Street. Stephen J. Stachowiak, 11838 Joseph Campau Avenue, is architect.

Mich., Sault Ste. Marie—Edison Sault Electric Co., Ashmun Street, has approved plans for immediate construction of new power station, 60 by 100 ft., near Meridian Street and Gros Cap Avenue, with installation to include a steam turbine-generator unit, three stoker-fired boilers and auxiliary equipment. Day & Zimmerman, Inc., Packard Building, Philadelphia, Pa., is consulting engineer.

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Mich., Traverse City—City Light and Power Department plans expansion and improvements in municipal power plant, including new 2500-kw. turbine-generator unit and auxiliary equipment. Estimates of cost and plans are being prepared by Hamilton & Weeber, Grand Rapids, Mich., consulting engineers.

N. C., Rocky Mount—Board of Public Utilities is considering extensions and improvements in municipal power plant, including installation of equipment for increased capacity. Cost estimated close to $800,000. Proposed to carry out work soon.

Ohio, Bluffton—Central Ohio Light & Power Co., Findlay, Ohio, has approved plans for expansion in Woodcock steam-electric power plant at Bluffton, and work is being placed under way. A new 7500-kw. turbine-generator unit and auxiliary equipment will be installed. Line extensions will be made.

Ohio, Painesville—Diamond Alkali Co., Oliver Building, Pittsburgh, Pa., plans installation of electric power equipment in new plant near Painesville, for production of magnesium for Government. It will comprise a series of large one and multi-story buildings. A power house will be built. Entire project will cost about $10,000,000. Fund in that amount will be secured from Defense Plant Corporation, Washington, D. C., a Federal agency.

Ohio, Toronto—Ohio Edison Co., Youngstown, Ohio, has authorized expansion in steam-electric power plant at Toronto, to include installation of new 40,000-hp. turbine-generator unit, high-pressure boiler and auxiliary equipment. Cost estimated about $3,500,000. Award for turbine-generator has been made to Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., and contracts for other equipment will be placed soon. Work will require about 24 mo. for completion.

Pa., Erie—Hammermill Paper Co., East Lake Road, will begin work soon on addition to boiler house at paper mill, about 40 by 50 ft., reported to cost close to $50,000, with boiler unit and auxiliary equipment. O. C. Schoenwerk, 3420 North Lake Shore Drive, Chicago, Ill., is consulting engineer.

Pa., Lock Haven—American Aniline Products, Inc., plans expansion in power station at local dye and chemical works, including installation of new turbine-generator unit, boiler and auxiliary equipment. This is part of an extension program to be carried out at works, entire project to cost over $300,000. Main offices are at 50 Union Square East, New York, N. Y.

R. I., Providence—Nicholson File Co., Acorn Street, plans new power house at plant, about 50 by 120 ft. Cost reported over $60,000, with boiler units and other equipment. Jenks & Ballou, Industrial Trust Building, Providence, are architects and engineers.

Texas, Corpus Christi—Central Power & Light Co., North Chapparral Street, will begin superstructure soon for addition to steam-electric generating station, to provide for installation of new turbine-generating unit and auxiliary equipment. Cost estimated close to $650,000. Sargent & Lundy, Inc., 140 South Dearborn Street, Chicago, Ill., is consulting engineer.

Va., Portsmouth—Water Department plans expansion in waterworks station, including installation of two gasoline engine-driven generator sets, two electric-operated pumping units and auxiliary equipment. Also will build two elevated steel tanks and towers, 1,000,000 gal. and 500,000 gal. capacity, respectively. Cost estimated about $500,000. Financing in that amount has been arranged through Federal aid.

Wis., Milwaukee—A. O. Smith Corporation, 3533 North Twenty-seventh Street, manufacturer of steel products, plans installation of electric power equipment in two one-story additions, 200 by 600 ft., and 300 by 400 ft., to be used for production of aircraft parts for Government. Fund of $2,760,000 will be secured through Defense Plant Corporation, Washington, D. C., a Federal agency, for project. Work will begin soon.

Wis., Washington Island—Washington Island Electric Co-operative, Inc., has plans maturing for new power plant, using Diesel engine-generating units and accessories. Cost close to $50,000. Work will be carried out under direction of Wisconsin Development Authority. Tenny Building, Madison, Wis., which is engineer for project.

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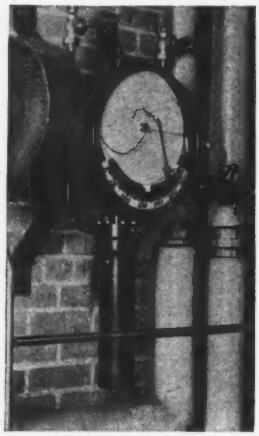

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